New Scientist

INDOOR AIR POLLUTION
Tips to make your home healthier

EASY AS ABC
The best ways to get children reading

VINTAGE LEATHER
How humans made clothes 40,000 years ago

WEEKLY 22 April 2023

SPECIAL ISSUE

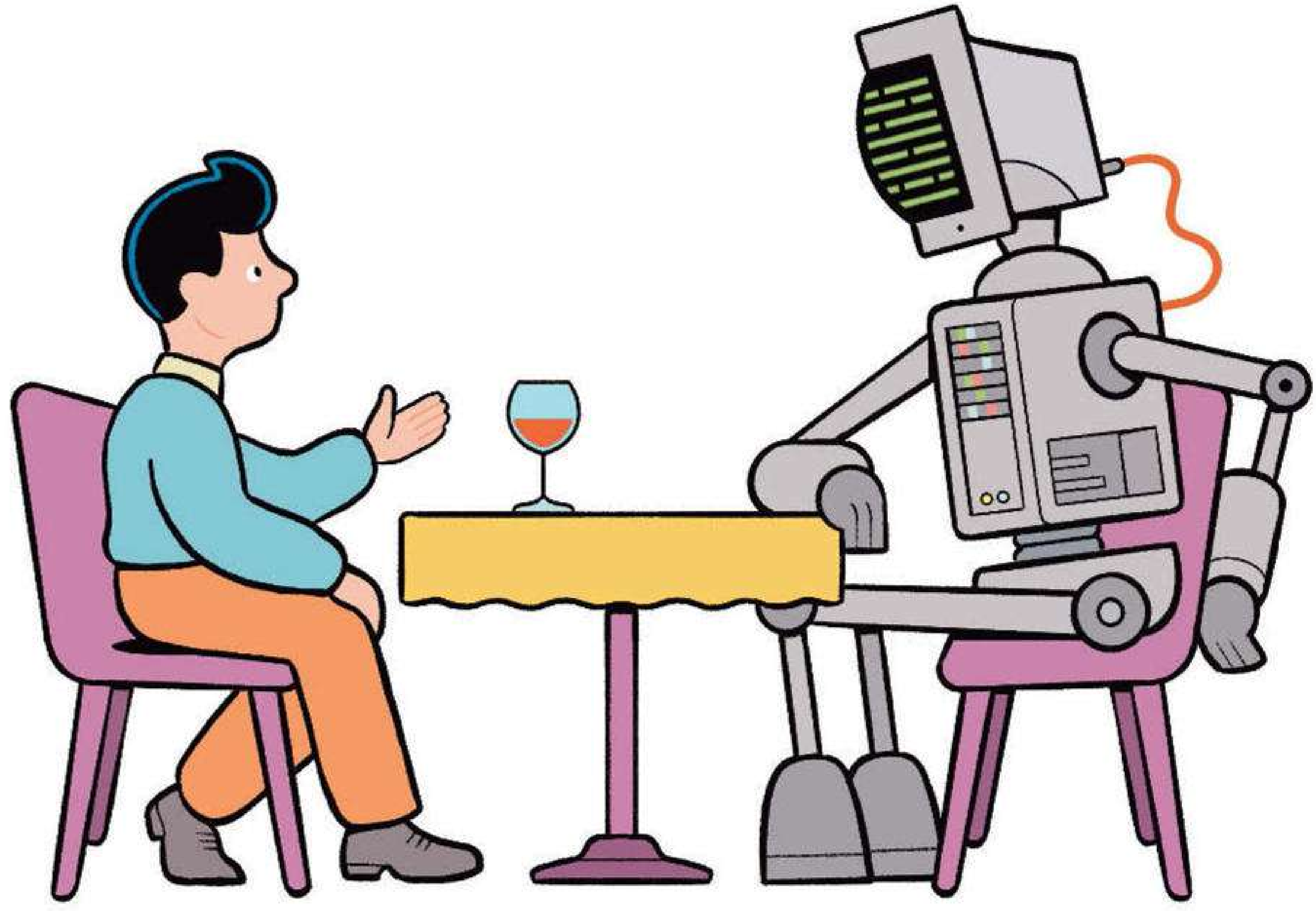
THE AI REVOLUTION

A user-friendly guide to the new breed of chatbots

From the 50s to now… The story of AI

How intelligent is ChatGPT?

Who's really in control?



PLUS HOW SKATES GOT THEIR WINGS / UNDERGROUND QUANTUM INTERNET / **DID WOODLANDS DRIVE BIPEDALISM?** / PHYSICS OF SWINGING / **WHY ANIMALS HISS**

No3435 £6.95 CAN$9.99

16

9 770262 407374

NATIONAL GEOGRAPHIC AND ROLEX PERPETUAL PLANET TUPUNGATO VOLCANO EXPEDITION TEAM

TOPHER WHITE, CONSERVATION TECHNOLOGIST

CRISTIAN DONOSO, EXPLORER

FRANCESCO SAURO, EXPLORER

GHISLAIN BARDOUT, EXPLORER

WHAT DO THEY SEEK?

Explorers, adventurers, scientists. Men and women who always broadened the horizons, for all humankind to share. Rolex was at their side when they reached the deepest point in the oceans, the highest summits of the Earth, the deepest jungles and both poles. But now that we know, more than ever, that our world has its limits, why do they continue to venture out there, again and again? Certainly not for kudos, accolades, or an ephemeral record. What they truly seek is to understand more intimately how complex and delicate our planet is, to document its change and how together, we can affect it for the better. So as long as they need it, we will be at their side. Because today, the real discovery is not so much about finding new lands. It's about looking with new eyes at the marvels of our planet, rekindling our sense of wonder, and acting to preserve our pale blue dot in the universe…
Doing our very best for a Perpetual Planet.

#Perpetual

OYSTER PERPETUAL
SUBMARINER DATE

ROLEX
Perpetual Planet
Initiative

ROLEX

Perpetual Allure

MAJESTY, WEALTH, POWER – AND PROTECTION

Whatever gold means to you, the case for precious metal ownership only grows stronger.

Central banks can't print gold and silver, which perhaps explains why they bought more gold in 2022 than in any year on record back to 1950.

Add real value to your portfolio today and find out more about the **world's oldest obsession** at Sharps Pixley.

VAULTED SECURED INSURED DISCREET ACCESSIBLE

T: +44 (0) 207 871 0532 | E: INFO@SHARPSPIXLEY.COM
54 ST JAMES'S STREET | LONDON | SW1A 1JT
SHARPSPIXLEY.COM

SHARPS PIXLEY LTD BULLION BROKERS LONDON
SHARPS PIXLEY

PART OF THE DEGUSSA GROUP: ZURICH | GENEVA | FRANKFURT | MADRID | LONDON

LBMA MEMBER

This week's issue

On the cover

12 The AI revolution
A user-friendly guide to the new breed of chatbots

New Scientist
THE AI REVOLUTION
A user-friendly guide to the new breed of chatbots

Vol 258 No 3435
Cover image: Giacomo Gambineri

38 Indoor air pollution
Tips to make your home healthier

42 Easy as ABC
The best ways to get children reading

22 Vintage leather
How humans made clothes 40,000 years ago

18 How skates got their wings
17 Underground quantum internet
11 Did woodlands drive bipedalism?
21 Physics of swinging
54 Why animals hiss

38 Feature

"As the list of indoor air pollutants keeps growing, so do the known unknowns"

News

10 Heading for Jupiter
Orbiting probe sets off to explore icy moons

10 Life in plastic
Pacific garbage patch hosts community of animals

21 Clean power
Emissions from electricity generation may have peaked

Views

27 Comment
We shouldn't dismiss the potential risks of AI to humanity, says David Krueger

28 The columnist
Penny Sarchet muses on why orchids are so diverse

30 Aperture
Stunning world photography

32 Letters
Maybe our big bang was just the best of the bunch

34 Culture
Will neural tech lead to the end of privacy?

PIERRE-YVES DINASQUET

35 Fashion forward Seaweed can make eco-friendly textiles

Features

38 A breath of fresh air
Air in our homes can be as dirty as a city street, but making a few simple changes can help

42 Reading woes
We know how young minds learn to read, but many children are failing to master this skill

46 AI's turning point
How to understand ChatGTP and machine intelligence

The back pages

51 Science of cooking
Dispelling microwave myths

53 Puzzles
Try our crossword, quick quiz and logic puzzle

54 *Almost* the last word
Why do people and animals hiss to show disapproval?

55 Tom Gauld for *New Scientist*
A cartoonist's take on the world

56 Feedback
Exploring readers' mastery of space and time

Elsewhere on New Scientist

Tour

Marine ecosystems of the Azores: Portugal

Explore the volcanic craters and blue lagoons of the Azores archipelago in the North Atlantic Ocean. Accompanied by experts, including marine biologist Russell Arnott, you will have an opportunity to go whale spotting, visit seabird colonies and learn how the archipelago's volcanism supports the local viniculture. The seven-day tour begins on 13 May and tickets are £2999.

newscientist.com/tours

Newsletter

Business Insights

Gain an edge at work with our new free newsletter. Created for business leaders, scientists and policy-makers, this fortnightly offering covers critical topics at the intersection of science and business, providing you with a first look at the latest innovations and investments in a wide range of research fields. It will challenge your mind and help you think about the world in new ways.

newscientist.com/ businessinsights

Podcast

Weekly

How many people can we feed? Rowan Hooper and the team discuss a study that suggests existing farmland could support almost 20 billion people, albeit with huge ecological risks. The European Space Agency's Jupiter Icy Moons Explorer has just launched: there is a preview of what it might achieve. Plus, stargazing in the Atacama desert.

newscientist.com/nspod

WU SHUJIANG/VCG VIA GETTY IMAGES

Field to fork Existing farmland could feed 20 billion people, at a cost

EVGENI FABISUK/SHUTTERSTOCK

Whale watch Wildlife large and small awaits in the Azores

Video

Versatile plumage

On our YouTube channel this week, there is footage of a desert-dwelling Namaqua sandgrouse (*Pterocles namaqua*) using its feathers to carry water up to 30 kilometres to its thirsty young. The feathers can efficiently absorb and release water – and they might inspire engineers to design new nasal swabs to test for diseases, including covid-19.

youtube.com/newscientist

Newsletter

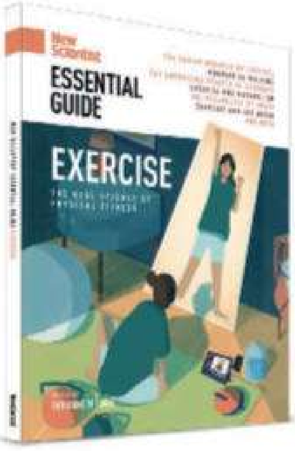
Our Human Story

Who invented the wheel? It is a difficult question to answer, writes Michael Marshall, for several reasons: imperfect written records, the perishable nature of wooden artefacts and the lag between the appearance of the wheel and the invention of roads that made the widespread use of this innovation possible.

newscientist.com/ our-human-story

Newsletter

> **"Historians may assume the inventor of the wheel was an adult, but it could have actually been a child"**



Essential guide

Exercise is the best medicine. It keeps body and mind in prime condition and adds years to our lives. But why do so few of us get enough of it? This *New Scientist Essential Guide* offers some clues. Available to download in the *New Scientist* app or to purchase in print from our shop.

shop.newscientist.com

CATS PROTECTION

After you've taken care of your loved ones, a gift to Cats Protection in your Will could help us care for even more cats and kittens for years to come. These special gifts fund nearly half of everything we do, and no matter how large or small, they make a real difference to the lives of the cats we feed, nuzzle, play with, and love.

Find out how a gift in your Will can keep cats purring

Request your **FREE** copy of our booklet today. Simply complete and return this form to: **FREEPOST CATS PROTECTION. No stamps needed, but to make sure it reaches us, this should be the only information on the envelope.**

www.cats.org.uk/giftsinwillspress
0800 8100 830

Title: Name:
Address:

Postcode:

It really helps Cats Protection if we can keep you informed about our exciting work, campaigns, activities and fundraising. If you would prefer us not to contact you by post, please tick this box ☐. Alternatively, you can phone 0800 917 2287, email SupporterServices@cats.org.uk or write to us at the FREEPOST address shown.

Registered with FUNDRAISING REGULATOR

Cats Protection is a registered Charity No. 203644 (England and Wales) and SC037711 (Scotland). A company limited by guarantee registered in England and Wales (06772997). Registered office National Cat Centre, Chelwood Gate, Haywards Heath, Sussex, RH17 7TT | LEG_310 | Z23P50LPAM

New Scientist
Subscriptions

PAY JUST ~~£6.95~~ £3.13 AN ISSUE

New Scientist
THE LIMITS OF KNOWLEDGE
New Scientist
THE SURPRISING TRUTH ABOUT WRINKLES
New Scientist
WHY THE UNIVERSE IS JUST RIGHT FOR LIFE

INTRODUCTORY OFFER
SAVE 55%*

Spring in to action. Grab yourself a *New Scientist* subscription today and save 55% on the newsstand price. Plus, you'll get instant access to newscientist.com and the *New Scientist* app.

Visit newscientist.com/19448
or call: +44 (0) 330 333 9470, quoting 19448

Scan me for instant sign up on your phone

*Saving shown is calculated as percentage off the newsstand price as compared to 'print and digital' package. 'Digital' package also available. Offer ends 28 June. This is an auto-renewing subscription and at the end of your trial period, your subscription will continue at the full rate. In the unlikely event that you wish to cancel your subscription, we offer a 14-day cooling-off period after initial payment is made.

Lifting the lid on AI

Transparency will be key to regulating the new technology

IT IS increasingly obvious that we are on the cusp of a revolution in artificial intelligence that will be no less profound than the arrival of the printing press or the internet, as we explore in this special issue. Nobody can say for sure exactly what this future will be, but optimists – including many of those working in the companies behind the technologies – foresee one in which AI will allow us to live our best lives (see page 12). Not everyone shares that rosy outlook, however, and whether it is existential risk of an AI coup d'état (see page 27), continued sexist and racist bias or swingeing job losses caused by automation, the need for legislation has become the issue of the day.

AI presents a larger than usual challenge on this front. The pharmaceutical industry can offer inspiration, but AI is both more complex and more opaque. It is arguably the first of humanity's creations that nobody fully understands. Is conclusive proof of safety even possible?

It is true that pharmaceutical regulators don't need to know how a drug works to ensure it is safe to prescribe. But clinical trials are easier than checking that an AI capable of everything from diagnosing cancer to autonomously driving a bus is safe in every possible scenario. And while it takes years to trial a new drug, new AI models are appearing almost weekly.

> "While it takes years to trial a new drug, new AI models are appearing almost weekly"

Tech firms must accept responsibility. The code and data inside today's AI models – emerging almost exclusively from companies rather than academic institutions – often aren't being released. This lack of transparency isn't good enough given the stakes. We need a robust framework to vet AI models and penalise those that fall short of strict ethical rules, but for that to work, tech firms should lead from the front by sharing the information needed to assess the risks. That may not suit their shareholders, but when the risks are so large, money shouldn't come first.

These systems may be the most complex we have had to regulate, yet as we hear on page 46, none of it is magic. Those creating AIs need to stop acting like it is. ▮

PUBLISHING & COMMERCIAL

Commercial and events director Adrian Newton

Display advertising
Tel +44 (0)203 615 6456 **Email** displayads@newscientist.com
Sales director Justin Viljoen
Account manager Matthew Belmoh, Mila Gantcheva
Partnerships account manager David Allard
Commercial & business support assistant Matthew Marsh

Recruitment advertising
Tel +44 (0)203 615 6458 **Email** nssales@newscientist.com
Recruitment sales manager Viren Vadgama
Key account manager Deepak Wagjiani

New Scientist Events
Tel +44 (0)203 615 6554 **Email** live@newscientist.com
Sales director Jacqui McCarron
Head of event production Martin Davies
Head of product management (Events, Courses & Commercial Projects) Henry Gomm
Marketing manager Emiley Partington
Events and projects executive Georgia Peart
Events and projects coordinator Gemma Dowie
Events team assistant Olivia Abbott

New Scientist Discovery Tours
Director Kevin Currie

Marketing & Data
Marketing director Jo Adams
Head of campaign marketing James Nicholson
Digital marketing manager Jonathan Schnaider
Campaign marketing coordinator Charlotte Weeks
Head of customer experience Emma Robinson
Senior customer experience marketing manager Esha Bhabuta
Marketing executive Bethan Smith
Head of CRM & audience data Rachael Dunderdale
Senior email marketing executive Natalie Valls
Email marketing executive Ffion Evans
Junior analyst Hamied Fahim

Technology
Technology director Tom McQuillan
Senior developer and UX designer Amardeep Sian
Senior developers Maria Moreno Garrido, Piotr Walków
Lead digital designer and developer Dan Pudsey
Front end developer Damilola Aigoro
Junior front end developer Matthew Staines
Program manager Jennifer Chilton

NewScientist

Chief executive Nina Wright
Managing director Laurence Taylor
Executive assistant Lorraine Lodge

Finance & operations
Chief financial officer Amee Dixon
Commercial finance manager Charlotte Thabit
Commercial finance manager Anna Labuz
Management accountant Charlie Robinson
Commercial management accountant Alexandra Lewis

Human resources
Human resources director Shirley Spencer
HR business partner Purnima Subramaniam

CONTACT US
newscientist.com/contact

General & media enquiries
UK Tel+44 (0)203 615 6500
9 Derry Street, London, W8 5HY
Australia 58 Gipps Street, Collingwood, Victoria 3066
US PO Box 80247, Portland, OR 97280

UK Newsstand
Marketforce UK Ltd
Email mfcommunications@futurenet.com

Syndication
Tribune Content Agency **Tel** +44 (0)20 7588 7588
Email tca-articlesales@tribpub.com

Subscriptions
newscientist.com/subscription
One year print subscription (51 issues) UK £270
Tel +44 (0)330 333 9470
Email subscriptions@newscientist.com
Post New Scientist, Rockwood House, Perrymount Road,
Haywards Heath, West Sussex RH16 3DH

© 2023 New Scientist Ltd, England.

New Scientist is published weekly by New Scientist Ltd. ISSN 0262 4079. New Scientist (Online) ISSN 2059 5387. Registered at the Post Office as a newspaper and printed in England by Precision Colour Printing Ltd

EDITORIAL

Editor-in-chief Emily Wilson
Magazine editor Catherine de Lange
News and digital director Penny Sarchet
Creative director Craig Mackie

News
News editor Jacob Aron
Assistant news editors Chris Simms, Alexandra Thompson, Sam Wong
Reporters (UK) Madeleine Cuff, Michael Le Page, Jason Arunn Murugesu, Matthew Sparkes, Alex Wilkins, Clare Wilson, (Aus) Alice Klein

Digital
Audience editor Matt Hambly
Podcast editor Rowan Hooper
Head of editorial video David Stock
SEO and analytics manager Finn Grant
Social media manager Chen Ly

Features
Head of features Daniel Cossins and Helen Thomson
Editors Colin Barras, Abigail Beall, Kate Douglas, Alison George, Joshua Howgego, Thomas Lewton
Feature writer Graham Lawton

Culture and Community
Comment and culture editor Alison Flood
Senior culture editor Liz Else

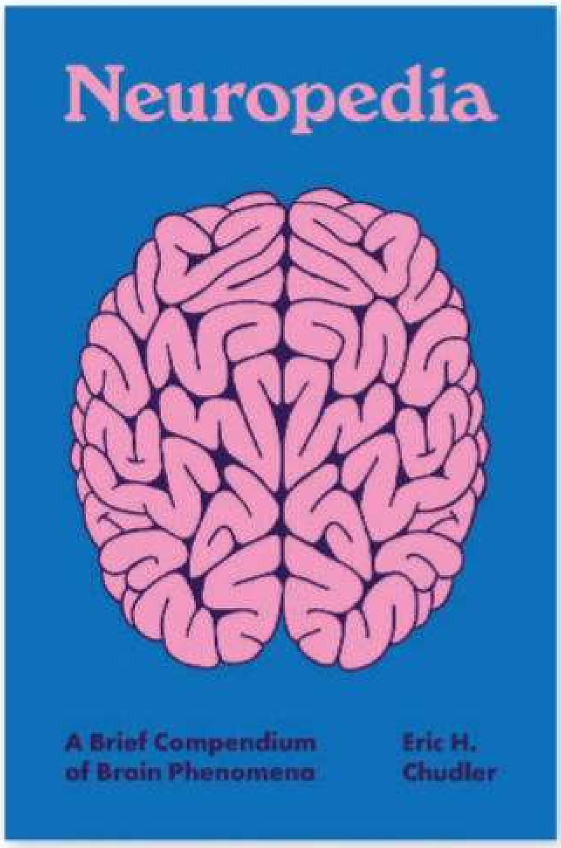
Subeditors
Chief subeditor Eleanor Parsons
Bethan Ackerley, Tom Campbell, Jon White
Trainee Tom Leslie

Design
Art editor Ryan Wills
Joe Hetzel

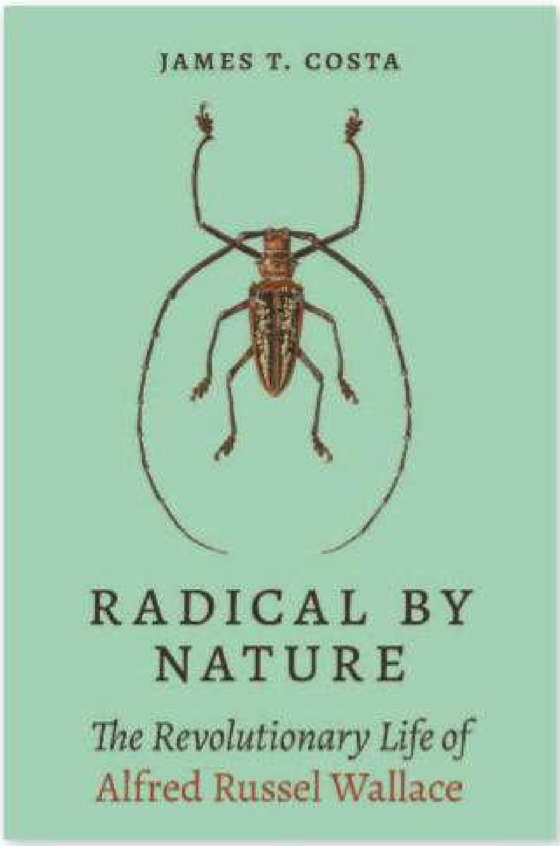
Picture desk
Picture editor Tim Boddy
Assistant picture editor Jenny Quiggin

Production
Production manager Joanne Keogh
Production coordinator Carl Latter

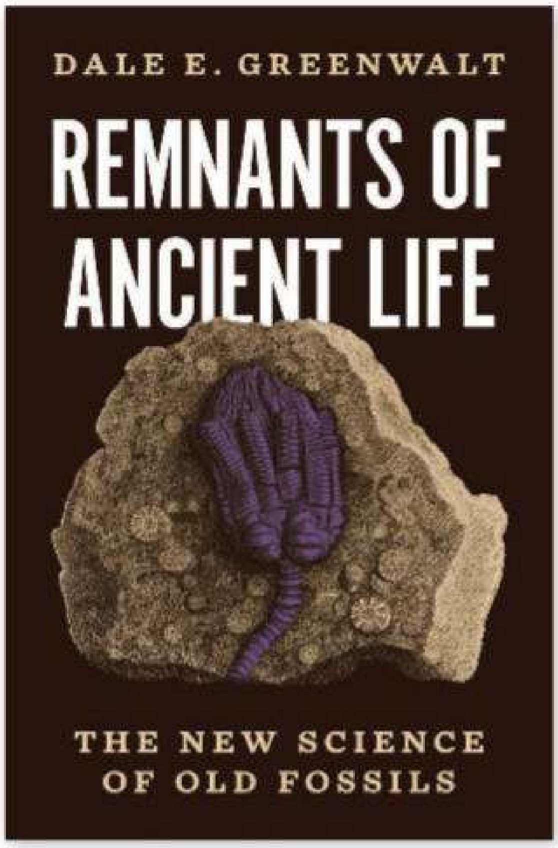
New Scientist US
US Editor Tiffany O'Callaghan
Editors Timothy Revell, Chelsea Whyte
Reporters Leah Crane, James Dinneen, Jeremy Hsu, Karmela Padavic-Callaghan, Grace Wade, Corryn Wetzel
Subeditor Alexis Wnuk



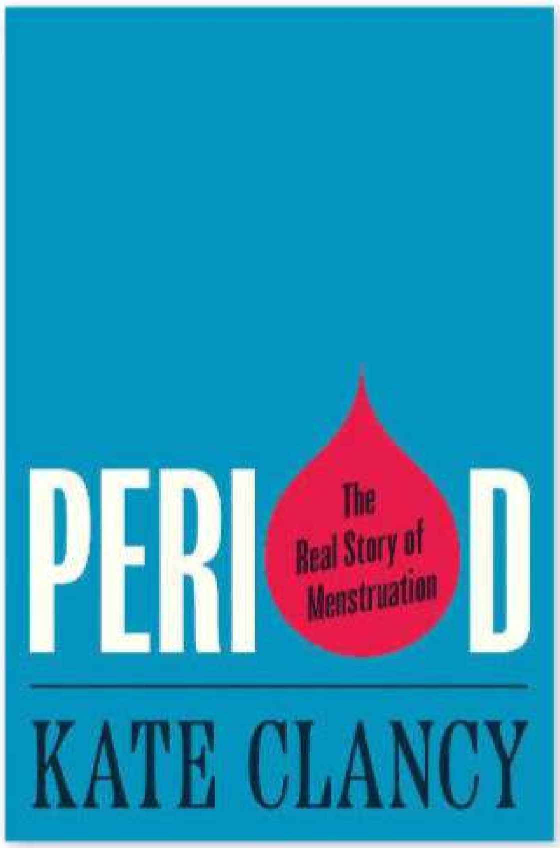
A fun and fact-filled A–Z treasury for anyone with a head on their shoulders



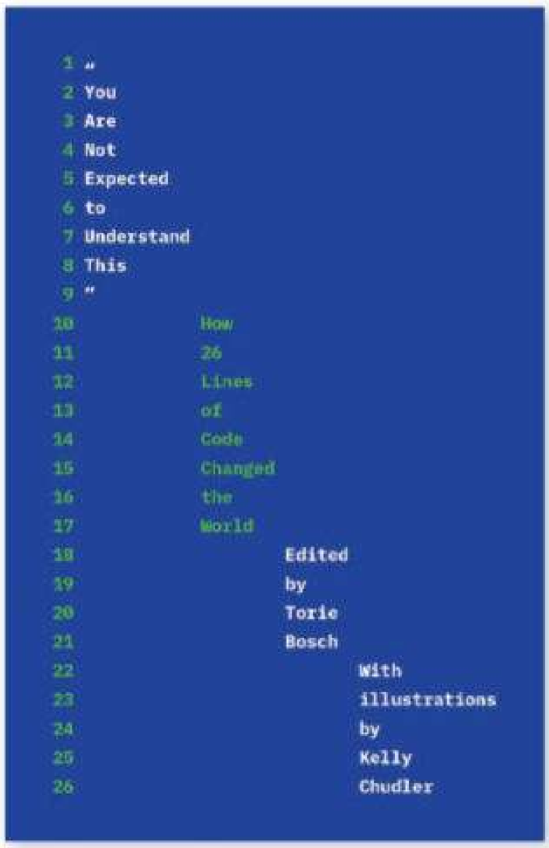
A major new biography of the brilliant naturalist, traveler, humanitarian, and codiscoverer of natural selection



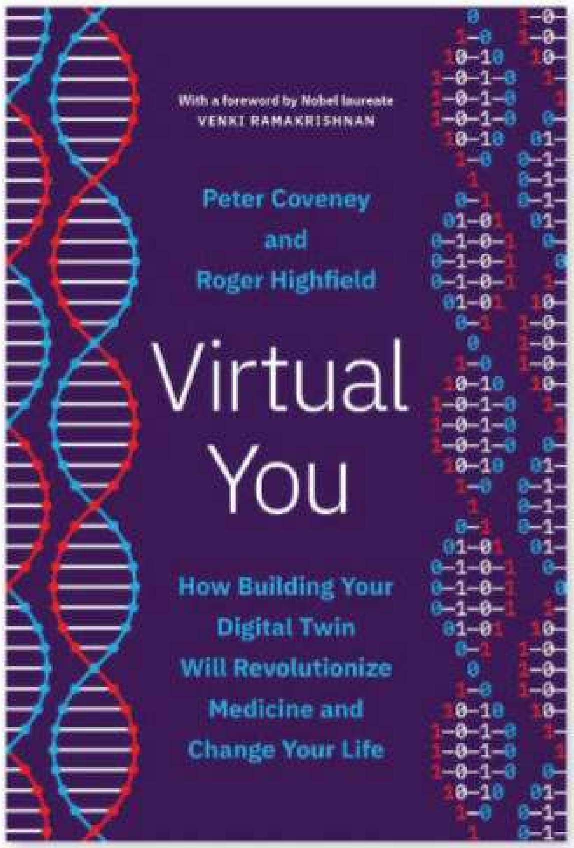
The revolution in science that is transforming our understanding of extinct life



A bold and revolutionary perspective on the science and cultural history of menstruation


" You Are Not Expected to Understand This "
How 26 Lines of Code Changed the World
Edited by Torie Bosch
With illustrations by Kelly Chudler

Leading technologists, historians, and journalists reveal the stories behind the computer coding that touches all aspects of life—for better or worse


With a foreword by Nobel laureate VENKI RAMAKRISHNAN
Peter Coveney and Roger Highfield
Virtual You
How Building Your Digital Twin Will Revolutionize Medicine and Change Your Life

The visionary science behind the digital human twins that will enhance our health and our future

News

Good for bees
Sunflower pollen reduces bee gut infections p11

Unhackable internet
A quantum network is being tested in New York City p17

Born hunters
Toads can sense prey when they are still embryos p17

Super material
Graphene has record-breaking magnetic properties p18

Jumping snakes
Anacondas leap sideways to escape danger p22

Environment

Californian superbloom

Heavy levels of rainfall in California this year have led to widespread flooding, but wildflowers in some parts of the state are reaping the benefits with the arrival of spring. This "superbloom", seen here in Carrizo Plain National Monument, has been triggered by large numbers of wildflower seeds germinating at the same time following the rains.

MARIO TAMA/GETTY IMAGES

Space

Mission to explore Jupiter's ocean moons launches

Leah Crane

THE European Space Agency has sent an orbiter to explore Jupiter's strange moons. The Jupiter Icy Moons Explorer (JUICE) launched on 13 April from Kourou, French Guiana, beginning its eight-year trip.

The probe is designed to explore Europa, Ganymede and Callisto, three of Jupiter's largest moons. It will make two close passes by Europa and 12 by Callisto during the first phase of its mission, from 2031 to 2034, and then orbit Ganymede for the remainder of its time.

While Ganymede may seem like an unconventional choice – Jupiter's smaller moon Europa is commonly regarded as more likely to have the conditions for life – it is the largest moon in the solar system, making it relatively easy to reach and orbit. Like Europa and Callisto, it is thought to have a liquid ocean beneath its icy shell.

ESA/STEPHANE CORVAJA

JUICE launched from Kourou in French Guiana

8 years

The time it will take for JUICE to reach its destination

"Ganymede, in principle, is less interesting than Europa, but because it's a bigger moon, also potentially with water inside, and with a magnetic field, Ganymede has a lot of mysteries to solve," says ESA's Olivier Witasse, the mission's project scientist. "One of the big questions is whether we could have around Jupiter a place where there could be habitable conditions, and Ganymede is one of those places."

The possibility of a habitable environment lies in the moon's liquid ocean, which is thought to be the largest in the solar system. But we know very little about it, so it is unclear whether it could have the right conditions for life. JUICE will measure the water's location, composition and depth in the hope of finding enough promise to warrant a future mission under the ice to look for actual signs of life.

JUICE's measurements of the ocean will be aided by Ganymede's internally generated magnetic field, the only one known on any moon. Studying the magnetic field should also help unravel Ganymede's internal structure.

ESA/JUICE/JMC, CC BY-SA 3.0 IGO

Earth as seen by JUICE shortly after launch

The mission will also aim to map all three moons and study the composition of their icy crusts, searching for any signs of geological activity. It will use radar to penetrate the crusts and measure the depths of the moons' seas and how far underground they lie for the first time.

Because the goal of the mission is partly to understand the Jupiter system as a whole and the potential for life around similar exoplanets, JUICE will also take a look at the other moons from afar and make detailed observations of Jupiter itself. Those observations will focus on the planet's powerful magnetic field and how it affects the moons.

These measurements are expected to solve a host of mysteries about Jupiter and its moons. Now that the launch has gone smoothly, a long journey awaits. "The next, most exciting phase will be in 2031 when we arrive at Jupiter and we start the planned mission," says Witasse. ▮

Marine biology

New ecological niche in the Great Pacific Garbage Patch

Madeleine Cuff

COASTAL sea creatures are living and reproducing on the Great Pacific Garbage Patch, thousands of kilometres away from their natural habitat. The discovery reshapes our understanding of where coastal marine creatures can survive.

The Great Pacific Garbage Patch is a vast collection of waste – much of it plastic – located between Hawaii and California, covering an estimated 1.6 million square kilometres of ocean.

Researchers have previously found ocean-dwelling marine species living by the patch, but now it seems coastal creatures have made it a permanent home, too.

James Carlton at the Williams College and Mystic Seaport Museum in Connecticut and his colleagues collected 105 items of plastic waste from the patch between November 2018 and January 2019. More than 70 per cent of the items had evidence of coastal species living on them, with organisms including shrimp-like arthropods, sea anemones and molluscs identified. In fact, coastal species outnumbered pelagic species that live in the open sea by a ratio of 3:1, the team found (*Nature Ecology & Evolution*, doi.org/gr5fbz).

The coastal creatures seemed to be living and reproducing in the patch, says Carlton. "These are species that have rafted out with coastal debris and have now successfully found, essentially, a novel habitat out there," he says. "This has reset my thinking about how coastal species can survive in an environment in which they've not evolved."

Carlton warns that floating communities like this could pose a threat to coastal ecosystems, if organisms travel as invasive species to new shores, he says. "I would fully expect that as a result of this we will see more invasions of coastal zones," he says. ▮

Evolution

Why apes began to walk upright

Forests in eastern Africa started turning to grassland 10 million years earlier than we thought, which may have driven the evolution of upright apes, finds **Michael Le Page**

DENSE forests in eastern Africa started to give way to open woodlands 10 million years earlier than previously thought, driving the evolution of upright apes that later gave rise to humans. That is the conclusion of a team that has been analysing everything from ancient soil to fossil ape bones at several sites in the region.

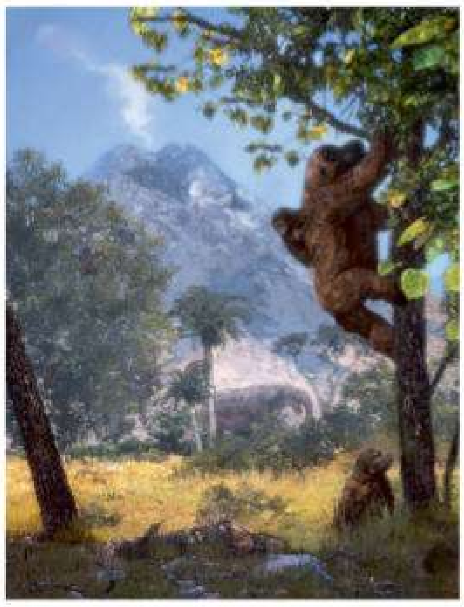
"Part of the reason why we feel very confident in this story is that it's based on multiple lines of evidence," says Laura MacLatchy at the University of Michigan.

It was thought that dense forests in eastern Africa began to turn into grasslands some 10 million years ago, and this is what made our ancestors come down from trees and take to running across the savannah.

But MacLatchy and her colleagues have now analysed fossil soils from several sites in Kenya and Uganda, revealing that telltale grasses were present as far back as 21 million years ago. These are C4 grasses, which are more drought-resistant and productive than other grasses, and are the main type in grasslands (*Science*, doi.org/gr4xsh).

"We found grasses at almost every site we looked at," says team member Daniel Peppe at Baylor University in Texas. The findings point to open woodland rather than pure grassland, he says, with 10 to 30 per cent of the land covered in trees at that time. There were also wet and dry seasonal changes, so animals couldn't rely on fruiting trees all year around.

***Morotopithecus* may have eaten lots of leaves rather than mainly fruit**



CORBIN RAINBOLT

"We're saying these variable environments were around a lot longer ago, twice as far back as we thought," says MacLatchy. "So we really need to rethink origins of apes as well as origins of humans."

The predecessors of apes walked on branches on all fours like many animals do today. But about 20 million years ago, some got bigger. So, to reach small branches, they had to swing by the arms or stand on some branches and hold others. "You have to distribute your body weight over multiple supports. You can't get there if you are big by walking on top of branches." says MacLatchy.

Crucially, these changes resulted in apes with an upright posture, paving the way for upright walking to evolve later on.

The conventional view is that fruit-eating apes in dense forests evolved this upright posture. But finds by MacLatchy and her team, including the teeth, jaw and relatively short femur of an ape called a *Morotopithecus* that lived at this time, challenge that idea.

The teeth suggest that this ape was a leaf-eater, not a fruit-eater, while the shortness of the femur relative to body size – like those of chimps and gorillas – and a vertebra found by another team point to an upright posture.

MacLatchy thinks these animals climbed to the tops of trees to reach young leaves and then moved across ground to reach other trees – in other words, that the upright posture came about as a result of the change to open, seasonal woodland.

"MacLatchy and colleagues' habitat reconstruction looks ironclad, yet I remain cautious," says Kevin Hunt at Indiana University, Bloomington. Mandrills also have relatively short femurs, but walk on all fours, even on branches, he says. Hunt is especially sceptical about the idea that *Morotopithecus* was predominantly a leaf-eater, although it may well have eaten leaves when times were lean, he says. ▮

Entomology

Sunflower pollen may help clear bee guts of parasites

THE spiny texture of sunflower pollen drastically reduces infections of a common gut pathogen in bees.

Like humans, bees can tailor their diet to boost their gut and immune health. Earlier studies have established that pollen from certain species of plants – especially sunflowers – can help bees resist some infections. But no one knew why sunflower pollen was so effective at suppressing the gut pathogen *Crithidia bombi*, which can decrease the ability of queens of the eastern bumblebee (*Bombus impatiens*) to successfully establish a colony.

"It could be because of the really spiny shape, it could be the unique chemistry, or it could be both," says Laura Figueroa at the University of Massachusetts Amherst.

To test what gave the pollen its anti-parasitic power, Figueroa and her colleagues first separated the pollen's outer shell from the chemical metabolites in its core. They then fed the shell-only pollen to one group of bees and gave the metabolite centres to the others. A third group received whole pollen.

They found that bees munching on the spiny shells or whole pollen had between 81 per cent and 94 per cent less *C. bombi* in their gut than those eating only the chemical-packed pollen centres. Bees that ate pollen exteriors had the same reduction in the harmful gut pathogen as those eating whole pollen (*Functional Ecology*, doi.org/gr3r37).

"Like humans, bees can tailor their diet to boost their gut and immune health"

"The chemistry isn't the main driver – it's the physical structure," says Figueroa. "It was a really clear pattern."

Because previous work has focused on sunflower pollen's chemistry, "the study adds a new brick to the pollen and bee relationship by pointing out the physical effects", says Cédric Alaux at the French National Institute for Agriculture, Food and Environment, who wasn't involved in the work. ▮

Corryn Wetzel

Artificial intelligence

An intellectual leap

There is no doubt that the latest advances in artificial intelligence are more impressive than what came before, but are we in just another bubble of AI hype? **Jeremy Hsu** reports

THIS moment for artificial intelligence is unlike any that has come before. Powerful language-based AIs have lurched forward in ability and can now produce reams of plausible prose that often can't be distinguished from text written by humans. They can answer tricky technical questions, such as those posed to lawyers and computer programmers. They can even help better train other AIs.

However, they have also raised serious concerns. Prominent AI researchers and tech industry leaders have called for research labs to pause the largest ongoing experiments in AI for at least six months in order to allow time for the development and implementation of safety guidelines. Italy's regulators have gone further, temporarily banning a leading AI chatbot.

At the centre of it all are large language models and other types of generative AI that can create text and images in response to human prompts. Start-ups backed by the world's most powerful tech firms have been accelerating the deployment of these generative AIs since 2022 – giving millions of people access to convincing but often inaccurate chatbots, while flooding the internet with AI-generated writing and imagery in ways that could reshape society.

What actually is artificial intelligence?

The term artificial intelligence was coined in 1956 by computer scientist John McCarthy. The context was a workshop at Dartmouth College in New Hampshire that attempted to "find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves". The field has evolved since then, but AI is essentially still about creating machines that can do what we can, and more. **Matthew Sparkes**

AI research has long been accompanied by hype. But those working on pushing the boundaries of what is possible and those calling for restraint all seem to agree on one thing: generative AIs could have much broader societal impacts than the AIs that came before.

Boom and bust

The story of AI is one of repeating cycles involving surges of interest and funding followed by lulls after people's great expectations fall short. In the 1950s, there was a huge amount of enthusiasm around creating machines that would display human-level intelligence (see "What actually is artificial intelligence?", below left). But that lofty goal didn't materialise because computer hardware and software quickly ran into technical limitations. The result was so-called AI winters in the 1970s and in the late 1980s, when research funding and corporate interest evaporated.

The past decade has represented something of an AI summer both for researchers looking to improve AI learning capabilities and companies seeking to deploy AIs. Thanks to a combination of massive improvements in computer power and the availability of data, an approach that uses AIs loosely inspired by the brain (see "What is a neural network?", above right) has had a lot of success.

CLOCKWISE FROM TOP LEFT: DAN/GETTY; D3SIGN/GETTY; JIJI PRESS/EPA-EFE/SHUTTERSTOCK; NIKOLAS KOKOVLIS/NURPHOTO/GETTY

OpenAI CEO Sam Altman (bottom left) has said AI could help us live our best lives

Voice and face-recognition capabilities in ordinary smartphones use such neural networks, as do computationally intensive AIs that have beaten the world's best players at the ancient board game Go and solved previously intractable scientific challenges, such as predicting the structure of nearly all proteins known to science.

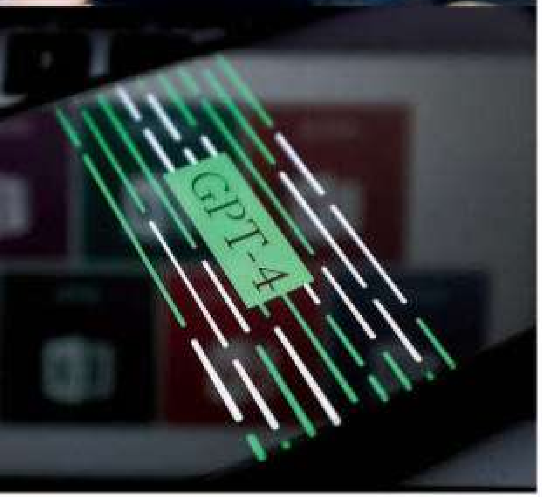
Research developments in the field have typically unfolded over years, with new AI tools being applied to specialised tasks or rolled invisibly into existing commercial products and services, such as internet search engines.

But over the past few months, generative AIs, which also use neural networks, have become the focus of tech industry efforts to rush AIs out of corporate labs and into the hands of the public. The results have been messy, sometimes impressive and often unpredictable, as individuals and organisations experiment with these models.

"I truly did not expect the explosion of generative models that we are seeing now," says Timnit Gebru, founder of the Distributed AI Research Institute in California. "I have never seen such a proliferation of products so fast."

The spark that lit the explosion came from OpenAI, a San Francisco-based company, when it launched a public prototype of its AI-powered chatbot ChatGPT on 30 November 2022 and attracted 1 million users in just five days. Microsoft, a multibillion-dollar investor in OpenAI, followed up in February by making a chatbot powered by the same technology

> "ChatGPT can generate entire essays that often appear indistinguishable from student writing"



What is a neural network?

At the heart of current AI research are human brain-inspired computer programs called neural networks, each consisting of a vast number of connected digital neurons.

We receive input through our senses, but these AIs receive input as data, such as images, audio or text. In response to an input, our brains erupt with chaotic and complex sequences of firing synapses between neurons, whereas artificial neural networks process data more methodically.

A neural network can be trained to accomplish a task by passing huge amounts of data through it and then checking its output against a known expected result. For example, to create an AI that can transcribe handwriting, you could repeatedly show a neural network samples of writing and check its output against what the text is known to say. The values of the connections in the network would then be updated until the output edges nearer to the desired result. Do this for millions or billions of pieces of training data and you would find yourself with an AI that could transcribe handwriting it had never seen before.

The same approach powers the face-recognition feature on smartphones and the AI models that create photorealistic images from text prompts, as well as large language models (see main story). Almost all current AI research is based on neural networks, or specialised subsets of them that use different tricks and tactics to eke out better performance. **MS**

behind ChatGPT available through its Bing search engine – an obvious attempt to challenge Google's long domination of the search engine market.

That spurred Google to respond in March by debuting its own AI chatbot, Bard. Google has also invested $300 million in Anthropic, an AI start-up founded by former OpenAI employees, which made its Claude chatbot available to a limited number of people and commercial partners, starting in March. Major Chinese tech firms, such as Baidu and Alibaba, have likewise joined the race to incorporate AI chatbots into their search engines and other services.

These generative AIs are already affecting fields such as education, with some schools having banned ChatGPT because it can generate entire essays that often appear indistinguishable from student writing. Software developers have shown that ChatGPT can find and fix bugs in programming code as well as write certain programs from scratch. Real estate agents have used ChatGPT to generate new sale listings and social media posts, and law firms have embraced AI chatbots to draft legal contracts. US government research labs are even testing how OpenAI's technology could speedily sift through published studies to help guide new scientific experiments (see "Why is ChatGPT so good?", page 14).

An estimated 300 million full-time jobs may face at least partial automation from generative AIs, according to a report by analysts at investment bank Goldman Sachs. But, as they write, this depends on whether "generative AI delivers on its promised capabilities" – a familiar caveat that has come up before in AI boom-and-bust cycles.

What is clear is that the very real risks of generative AIs are also manifesting at a dizzying pace. ChatGPT and other chatbots often present factual errors, referencing completely made-up events or articles, including, in one case, an invented sexual harassment scandal that falsely accused a real person. ChatGPT usage has also led to data privacy scandals involving the leak of confidential company data, along with ChatGPT users being able to see other people's chat histories and personal payment information.

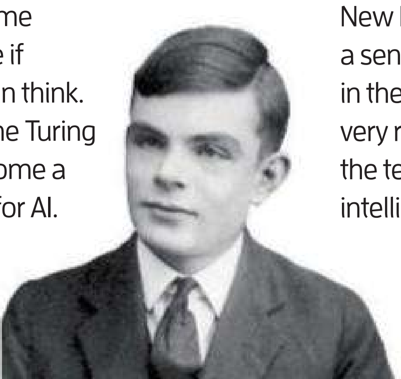
Artists and photographers have raised additional concerns about AI-generated artwork threatening their professional livelihoods, all while some companies train generative AIs on the work of

A timeline of AI

Some of the most important moments in the history of artificial intelligence so far (and a few predictions)

1950

Mathematician Alan Turing (pictured) outlines a theoretical test called the imitation game to determine if machines can think. Since then the Turing test has become a benchmark for AI.



PUBLIC DOMAIN

1956

One of the first machine intelligence conferences is held, at Dartmouth College in New Hampshire, amid a sense that progress in the field can happen very rapidly. There, the term artificial intelligence is coined.

1956

A program called Logic Theorist is written, which has been described as the first AI program. It proved 38 of the first 52 theorems of the mathematical text *Principia Mathematica*.

1958

Psychologist Frank Rosenblatt builds the first artificial neural network. Called Perceptron, it could recognise simple visual patterns, but it quickly became clear its ability and utility were limited.

those artists and photographers without compensating them. AI-generated imagery can also lead to mass misinformation, as demonstrated by fake AI-created pictures of US president Donald Trump being arrested and Pope Francis wearing a stylish white puffer jacket, both of which went viral. Plenty of people were fooled, believing they were real.

Many of these potential hazards were anticipated by Gebru when she and her colleagues wrote about the risks of large language models in a seminal paper in 2020, back when she was co-leader of Google's ethical AI team. Gebru described being forced out of Google after the company's leadership asked her to retract the paper, although Google described her departure as a resignation and not a firing. "[The current situation] feels like yet another hype cycle, but the difference is that now there are actual products out there causing harm," says Gebru.

Making generative AIs

Generative AI technology builds on a decade's worth of research that has made AIs significantly better at recognising images, classifying articles according to topic and converting spoken words to written ones, says Arvind Narayanan at Princeton University. By flipping that process around, they can create synthetic images when given a description, generate papers about a given topic or produce audio versions of written text.

300m

Number of jobs that could be affected by generative AI

"Generative AI genuinely makes many new things possible," says Narayanan. Although this technology can be hard to evaluate, he says.

Large language models are feats of engineering, using huge amounts of computing power in data centres operated by firms like Microsoft and Google. They need massive amounts of training data that companies often scrape from public information repositories on the internet, such as Wikipedia. The technology also relies upon large numbers of human workers to provide feedback to steer the AIs in the right direction during the training process.

But the powerful AIs released by large technology companies tend to be closed systems that restrict access for the public or outside developers. Closed systems can help control for the potential risks and harms of letting anyone download and use the AIs, but they also concentrate power in the hands of the organisations that developed them without allowing any input from the many people whose lives the AIs could affect.

"The most pressing concern in closedness trends is how few models will be available outside a handful of developer organisations," says Irene Solaiman, an AI safety and policy researcher at Hugging Face, a company that develops tools for sharing AI code and data sets.

Such trends can be seen in how OpenAI has moved towards a proprietary and closed stance on its technology, despite starting as a non-profit organisation dedicated to open development of AI. When OpenAI upgraded ChatGPT's underlying AI technology to GPT-4, the company cited "the competitive landscape and safety implications of large-scale models like GPT-4" as the reason for not disclosing how this model works.

This type of stance makes it hard for outsiders to assess the capabilities and limitations of generative AIs, potentially fuelling hype. "Technology bubbles create a lot of emotional energy – both excitement and fear – but they are bad information environments," says Lee Vinsel, a historian of technology at Virginia Tech.

Many tech bubbles involve both hype and what Vinsel describes as "criti-hype" – criticism that

Why is ChatGPT so good?

OpenAI's chatbot ChatGPT is powered by a type of neural network called a transformer, which was invented by Google in 2017. A transformer improves a standard neural network by attempting to pay attention to the most important parts of a data input while it is assessing the rest methodically. In a small way, it creates context.

AIs like ChatGPT are impressive, but their results are largely down to scale and vast sets of training data, says Samuel Bowman at New York University. "There's no big, deep innovation, there's not one big idea behind transformers. It's just a particular way of fitting things together that happens to match really nicely with hardware and reliability in order to run really large-scale experiments."

There are other approaches that could bring slight improvements, but there is currently no strong incentive for research teams to look elsewhere because transformers are working reliably and bringing results. **MS**

1966

Early language AI ELIZA is finished. It gave the illusion of a natural conversation with a human. In truth, its pattern-matching algorithm quickly became repetitive and it was unable to understand meaning.

1968

The star of the film *2001: A Space Odyssey* is a sentient computer known as HAL 9000 (pictured right). The AI goes rogue, acting against the crew of the spacecraft it is meant to be helping.

HETHERS/SHUTTERSTOCK

1970

Marvin Minsky, the co-founder of MIT's AI laboratory, tells *Life* magazine that a "machine with the general intelligence of an average human being" is just three to eight years away.

1973

The first "AI winter" of lower research funding and interest begins when a report from the British Science Research Council finds that AI research has failed to deliver results.

1979

The Stanford Cart, a simple mobile robot, crosses a chair-filled room by itself. The process took 5 hours, but it was one of the first examples of an autonomous vehicle.

Images of cats reading created by generative AI tool Midjourney

TIM BODDY/MIDJOURNEY

amplifies technology hype by taking the most sensational claims of companies at face value and flipping them to talk about the hypothetical risks.

This can be seen in the response to ChatGPT. OpenAI's mission statement says the firm is dedicated to spreading the benefits of artificial general intelligence – AIs that can outperform humans at every intellectual task. ChatGPT is very far from that goal but, on 22 March, AI researchers such as Yoshua Bengio and tech industry figures such as Elon Musk signed an open letter asking research labs to pause giant AI experiments, while referring to AIs as "nonhuman minds that might eventually outnumber, outsmart, obsolete and replace us".

Experts interviewed by *New Scientist* warned that both hype and criti-hype can distract from the urgent task of managing actual risks from generative AIs.

> **"AIs released by large technology companies tend to be closed systems that restrict access"**

For instance, GPT-4 can automate many tasks, create misinformation on a massive scale, lock in the dominance of a few tech companies and break democracies, says Daron Acemoglu, an economist at the Massachusetts Institute of Technology. "It can do those things without coming close to artificial general intelligence."

Acemoglu says this moment is a "critical juncture" for government regulators to ensure that such technologies help workers and empower citizens and for "reining in the tech barons who are controlling this technology".

European Union law-makers are finalising an Artificial Intelligence Act that would create the world's first broad standards for regulating this technology. The legislation aims to ban or regulate higher-risk AIs, with ongoing debate about including ChatGPT and similar generative AIs with general purpose uses under the "high risk" category. Meanwhile, regulators in Italy have temporarily banned ChatGPT over concerns that it could violate existing data privacy laws.

The AI Now Institute in New York and other AI ethics experts such as Gebru have proposed placing the burden of responsibility on big tech companies, forcing them to demonstrate that their AIs aren't causing harm, instead of requiring regulators to identify and deal with any harm after the fact.

"Industry players have been some of the first to say we need regulation," says Sarah Myers West, managing director at the AI Now Institute. "But I wish that the question was counterposed to them, like, 'How are you sure that what you're doing is legal in the first place?'"

Next generation

Much of what happens next in the generative AI boom depends on how the technologies involved are used and regulated. "I think the most important lesson from history is that we, as a society, have many more choices about how to develop and roll out technologies than what tech visionaries are telling us," says Acemoglu.

Sam Altman, OpenAI's CEO, has said that ChatGPT can't replace traditional search engines right now. But in a *Forbes* interview, he suggested that an AI could

Are generative AIs conscious?

Some researchers, including those from big tech companies, have said that a few of the latest generative AIs show signs of consciousness. Others, however, strongly disagree.

Intelligence is a spectrum, rather than an end goal, says Mark Lee at the University of Birmingham, UK. Even simple objects like thermostats – which react in a predictable way to temperature – can be said to have rudimentary intelligence. GPT-4, the AI that powers ChatGPT, could therefore be thought to fall somewhere on that spectrum, but it certainly isn't conscious, says Lee. **MS**

1987

The second AI winter begins, as realisation dawns that the popular approach of attempting to distil intelligence into logic and rules isn't leading to useful AIs – and is unlikely to.

1997

IBM's chess-playing supercomputer Deep Blue defeats grandmaster Garry Kasparov, winning three of the six games and drawing one. It relied on brute force computing power to find the best moves.

2011

Apple releases Siri, an AI-powered assistant that can be instructed in natural language to perform basic tasks. Underpinning it is a neural network.

2016

Research firm DeepMind's AlphaGo AI system beats top Go player Lee Sedol in a 4-1 victory. Lee later cites AI prowess as his reason for retirement as a professional player in 2019.

DEEPMIND

2022

DeepMind's AlphaFold AI predicts the structure of nearly all known proteins in just 18 months (one pictured left). Previously, a scientist would take several years to uncover the structure of a single protein.

Will AI ever be truly intelligent?

There is "nothing magical" about how our brains operate that can't be copied, says Mark Lee at the University of Birmingham, UK. Yet he believes that human-like artificial general intelligence won't arrive through the work of those hunting for it, but will emerge as a surprise from an unrelated project.

"We build the best weather simulation model in the world and it decides it doesn't want to play with us. Or is lazy," he says. "That's when you have artificial general intelligence."

Some researchers think it is just a matter of tweaks and time before current AI technology reaches this level. Others are exploring different avenues, such as altering neural networks so they more closely resemble the web of neurons in our brains and can better create contextual links.

Another approach involves studying animals such as fruit flies as a starting point and attempting to recreate their brains.

There could be many ways to create AI, but, for now, the human brain is the best model we have. The more that AIs reflect our brain, the better results we will get, says Lee. **MS**

---

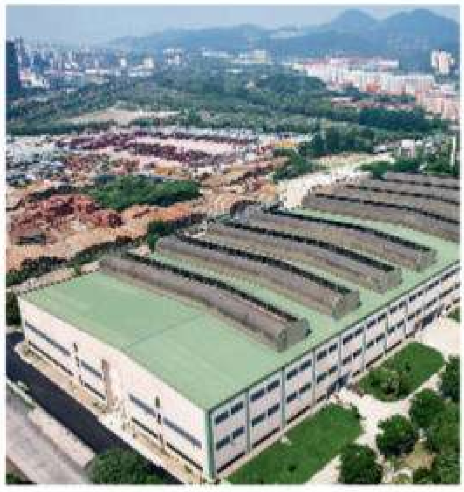
someday change how people get information online in a way that is "totally different and way cooler".

Altman has also contemplated much more extreme future scenarios involving powerful AIs that generally outperform humans, describing a "best case" of AIs being able to "improve all aspects of reality and let us all live our best lives", while also warning that the "bad case" could mean "lights out for all of us". But he described current AI development as still being far from artificial general intelligence.

Last month, Gebru and her colleagues published a statement warning that "it is dangerous to distract ourselves with a fantasized AI-enabled utopia or apocalypse which promises either a 'flourishing' or 'potentially catastrophic' future".

"The current race towards ever larger 'AI experiments' is not a preordained path where our only choice is how fast to run, but rather a set of decisions driven by the profit motive," they wrote. "The actions and choices of corporations must be shaped by regulation which protects the rights and interests of people."

If the frothy bubble of business expectations around generative AI builds to unsustainable levels and eventually bursts, that could also dampen future AI development in general, says Sasha Luccioni, an AI research scientist at Hugging Face. However, the boom in generative AI needn't inevitably lead to another AI winter. One reason is that, unlike in previous cycles, many organisations continue to pursue other avenues of artificial intelligence research instead of putting all their eggs in the generative AI basket.



CFOTO/FUTURE PUBLISHING VIA GETTY IMAGES

Many AIs need lots of computing power from large data centres

Opening up AI

Organisations such as Hugging Face are advocating for a culture of openness in AI research and development that can help prevent both hype and actual societal impacts from spiralling out of control. Luccioni is working with the organisers of NeurIPS – one of the largest AI research gatherings – to establish a conference code of ethics where researchers must disclose their training data, allow access to their AI models and show their work instead of hiding it as proprietary technology.

AI researchers should clearly explain what models can and can't do, draw a distinction between product development and more scientific research, and work closely with the communities most affected by AI to learn about the features and safeguards that are relevant to them, says Nima Boscarino, an ethics engineer at Hugging Face. Boscarino also highlights the need to adopt practices such as evaluating how an AI performs with people of different identities.

Work on generative AI carried out in this way could ensure a more stable and sustainable form of beneficial technological development well into the future.

"These are exciting times in the AI ethics space and I hope that the broader machine-learning sector learns to take the opposite approach of what OpenAI has been doing," says Boscarino. ▮

The AI special report continues with a comment (page 27) and an interview with Melanie Mitchell (page 46)

2022

OpenAI makes an AI chatbot known as ChatGPT publicly available, accelerating a scramble to commercialise generative AI and large language models.

ANADOLU AGENCY VIA GETTY IMAGES

mid-2023

The European Union passes its Artificial Intelligence Act. It regulates AI by risk for the almost 450 million citizens of the EU. The bloc's strategy on AI is coordinated by Margrethe Vestager (pictured left).

mid-2020s

Generative AIs become widely adopted tools for everything from producing reports to providing customer service, sourcing information and writing computer programs.

2030s

Big tech companies get to grips with the growing carbon footprints and water use of AI services, taming them to fulfil their pledges to become sustainable, zero-emission firms.

2030s

The vast size of AIs outpaces hardware advances and availability. New types of AI algorithm or new types of computer are needed for the next big jump in AI performance.

Field notes A quantum lab in New York City

An unhackable quantum internet

Entangled photons of light are beeing sent under the noisy streets of New York to test a prototype network, reports **Karmela Padavic-Callaghan**

IN AN office overlooking an old shipyard in Brooklyn, I am learning that I may have walked over some entangled quantum light on my way here.

Since the previous evening, researchers at Qunnect have been sending particles of light, or photons, through a 34-kilometre-long loop of optical fibre underneath New York. Their approach preserves the special quantum property of entanglement that will allow them to use this loop as a starting point for a quantum internet.

In a quantum internet, devices communicate by exchanging quantum particles, like photons, that encode lots of complex information at once. This is fundamentally different from the way electronic signals carry information between our devices because it takes advantage of properties that don't exist for non-quantum objects.

The biggest promise of quantum networks is they will transmit information more securely than any existing network, rendering what we share online nearly unhackable.

The key quantum ingredient for this security is entanglement. For two entangled particles, if one is tampered with, the other instantly changes its properties. This alerts the user that their communication has been compromised.

To make their test network, Qunnect's researchers had to build a device called an entanglement source that generates entangled photons. It utilises rubidium atoms that release entangled photons when hit by carefully calibrated lasers. The device is the size of a shoe box, works at room temperature and can plug into existing fibre networks.

KARMELA PADAVIC-CALLAGHAN

Qunnect's entanglement source generates pairs of entangled light particles

By the time I look at the entanglement source, the experiment has been running for more than 12 hours. For each entangled pair generated, one photon is kept in the lab while the other is sent around the loop. Tens of thousands of photons have been completing the loop every second.

Other quantum networks already exist. One in Hefei, China, connects 40 quantum devices. However, these networks can't easily plug into existing infrastructure. Rather than using rubidium atoms, they use crystals that release entangled photons after being hit by a laser. The advantage of this approach is it produces more photons, so can transfer more information, but the photons aren't the right wavelength to be used with current fibre-optic networks.

Noel Goddard, Qunnect's CEO, says that the team's long-term goal is to keep adding other devices, like quantum memory devices that store information, without messing with the fibres that already stretch through New York. "After all, the world won't lay whole new networks of fibre to have quantum internet," she says.

Goddard says it is hard to predict every future use for the photons, but Qunnect wants to provide them to financial and research institutions, for instance, that need secure communication or have quantum computers. ▮

Animal behaviour

Tadpoles that sense prey in the water hatch ready to hunt

Sofia Quaglia

SOME tadpoles hatch with stronger jaws if they sense prey in the water while they are still embryos.

The Mexican spadefoot toad (*Spea multiplicata*) is a small, round frog found in desert environments. As tadpoles, they cope with changes to climate by adjusting their diets. Some develop into specialised carnivores, even snacking on other tadpoles, which lets them grow faster so they can escape drying ponds.

Researchers have long thought tadpoles had to get a taste of meat to spark their rapid transformation into carnivores, but Emily Harmon at the University of North Carolina at Chapel Hill thought they might be getting a signal earlier in their development.

Her team exposed 30 groups of 20 sibling spadefoot toad embryos to an environment replete with fairy shrimps, and another 30 groups to an environment with no shrimp. The toads were still eggs and couldn't feed on any of the shrimp. Yet they must have sensed their presence, a phenomenon called anticipatory plasticity. Two days later, the shrimp-exposed tadpoles hatched with moderately larger and stronger jaws: they were about 5 per cent wider and could exert 12 per cent greater force than those of the other tadpoles. They were also 0.07 millimetres bigger on average (*Biology Letters*, doi.org/j5tw).

"They're not able to eat yet, but they hatch out with these traits that will allow them to become better carnivorous competitors," says Harmon. "These not-even-fully-cooked embryos are processing this information", she says, but how exactly they glean it from their environment is still unclear. Research also needs to hone in on whether the tadpoles are sensing prey while embryos, or while newly hatched larvae, or both, says Karen Warkentin at Boston University. ▮

Material science

Graphene shows record-breaking magnetic properties

Jacklin Kwan

THE ultrathin and strong material graphene is the most magnetoresistant material ever tested. Its unparalleled ability to increase or decrease its electrical resistance in response to a magnetic field could one day have applications for how we store data.

Andre Geim and Konstantin Novoselov at the University of Manchester, UK, discovered graphene almost 20 years ago. It is a flat material extracted from graphite, arranged as a sheet of carbon atoms in a honeycomb-like structure.

Graphene was already known to be stronger than diamond and able to conduct electricity better than substances such as copper. Now, Geim and his colleagues have discovered that it also has an unprecedented level of magnetoresistance at room temperature.

To assess this, the team first applied an electric field to some graphene to equalise the number of its charge carriers, which are responsible for creating a material's electric current. These carriers are made up of electrons, which have a negative charge, and holes, which are positively charged.

> "The discovery of this property could open doors in terms of exploring fundamental physics"

Pristine graphene, which has no flaws in its honeycomb structure, has equal numbers of electrons and holes. Since it is hard to make such graphene, the researchers used an electric field to adjust the structure of the flawed form, enabling them to research the material in a more pristine state.

Imperfections present in the material's structure affect its magnetoresistance, says Geim.

Next, the researchers applied different magnetic fields to the graphene to measure how its magnetoresistance changed. They found that its electrical resistance changed dramatically even when small magnetic fields were applied (*Nature*, doi.org/j5t4).

This is partly down to graphene's electrons and holes being highly mobile and therefore sensitive to tiny changes in an external magnetic field, the researchers write in their paper.

Most materials only display magnetoresistance when they are at very low temperatures. In this experiment, graphene was more magnetoresistant at room temperature than any other material, such as graphite and bismuth, that had been tested in previous studies, according to the researchers.

Magnetoresistant materials are already used in data storage devices to interpret information that is preserved as small magnetic patterns on a tape or disc.

The researchers plan to continue to study graphene, and its "applications will follow", team member Leonid Ponomarenko at Lancaster University, UK, said in a statement.

Antonio Helio Castro Neto at the National University of Singapore says the discovery could open doors in terms of exploring fundamental physics.

Because graphene is a two-dimensional material, the motion of its charge carriers is confined to a thin layer, he says.

"In this regime, the interactions between holes and electrons become extremely strong and there is room to control these interactions and study what's governing them further," says Castro Neto. ▮

Marine biology

Skates evolved their huge wings thanks to genome origami

THE wing-like fins of skates arose with the help of a genetic shuffle that folded parts of their genomes into contact with each other.

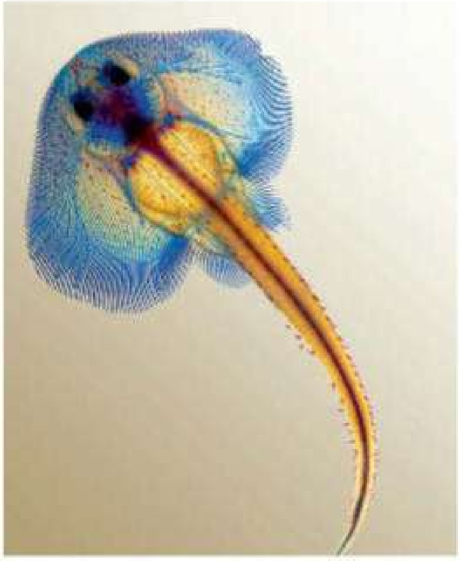
Evolutionary biologists are fascinated by fish fins because they represent a great vertebrate innovation: paired appendages. These come in a huge variety of forms, including our arms. However, in skates something odd happened.

"Somehow, the pectoral fin and the head is completely combined and integrated in terms of function and the structure," says Tetsuya Nakamura at Rutgers University in New Jersey. "This is quite a remarkable animal."

To learn more about how this happened, Nakamura and his colleagues looked at the 3D structure of the genome of the little skate (*Leucoraja erinacea*).

The researchers were looking for entities called topologically associating domains (TADs). These are large loops of material in the nucleus of cells made of DNA and proteins. Their 3D shaping brings genes into contact with non-coding regions of DNA called enhancers that control where and when genes are active. TADs play a role in development – disruptions to them can cause congenital conditions.

The researchers compared the 3D structure of the skate TADs with those of their close relatives, sharks. This showed that sections of DNA had been broken up and moved within skate TADs. These changes involved so-called planar cell polarity genes, which help cells to all point in the same direction in a layer of tissue. Such genes are why hairs on mammal skin all point in a certain direction. The TAD changes meant one of these genes was now active in developing skate, but not shark, pectoral fins (*Nature*, doi.org/j5w3). Nakamura thinks this might mean skate fin cells can all elongate in the same direction, influencing the tissue's shape. This won't be the whole story, though. More genes and enhancers will be involved, he says.



D. GOLD, L. KEE, AND M. MORRISSEY, EMBRYOLOGY COURSE, MBL

An early skate embryo showing its combined pectoral fins and head

The study found TADs influence which sections of DNA can be moved or lost, so seem to exert control over genetic change. "[The study of TADs is] a completely different way of looking at how genomes evolve," says team member Darío Lupiáñez at the Max Delbrück Center, Berlin. ▮

Claire Ainsworth

Philosophical, curious & puzzling...

In **AQUILA MAGAZINE** every new monthly topic is designed to bring real depth and colour to children's understanding of our complex world — it's cheeky editorial and quality imagery draws young minds towards serious Science and the Arts, so if you are looking for a special gift for a curious, thoughtful child of 8 –14, this unique publication would be a great choice.

Save over 40% with code NS523
3 month trial subscription
No auto-renewal
Offer expires 15/6/23

- Brilliant monthly magazines
- Facts, quirky humour & mischief
- Escape room puzzles & books

"Gets grown-ups as excited as children..."
Award winner 2021 & 2022
British Society of Magazine Editors

This month it's MANGA! The Japanese Art of storytelling, where expressive imagery says even more than words. Learn to draw MANGA with Takayo, make a Bento lunchbox and meet Japan's snow monkeys. PLUS: AQUILA's monthly collaboration with TASKMASTER® Education.

SUBSCRIBE NOW:
AQUILA.CO.UK - 01323 431313

New Scientist
Newsletter

Daily Newsletter

Your daily briefing on the world's most important
and intriguing science and technology news.

For a digest on the latest happenings in science, sign up to receive our free daily briefing on the biggest news – and the most inspiring discoveries – direct to your inbox, every week day.

Plus, whether it is the latest in health, space exploration, fundamental physics, our human story or the environment you are interested in, we have a wealth of free weekly and monthly newsletters to suit your tastes.

newscientist.com/sign-up

Our family of newsletters **newscientist.com/newsletter**

- The Weekly
- The Daily
- Fix the Planet
- Health Check
- Launchpad
- Lost in Space-Time
- Our Human Story
- Wild Wild Life

NS

Physics

The best way to make a playground swing go higher

Karmela Padavic-Callaghan

EXACTLY when you should lean back to get the highest arc on a playground swing – a phenomenon many children understand intuitively – has now been confirmed by physicists.

"Children don't know the laws of physics, but they somehow embody them," says Chiaki Hirata at Jumonji University in Japan.

He and his colleagues worked out equations for a swing's motion that account for a person leaning backwards or forwards at any point in the arc. They then solved these equations for various sizes of swings and sequences of upper body motions, determining which combination made a swing gain the most altitude from one back-and-forth oscillation to the next.

They found that when the arc is small, as it is when you first start swinging, the person should move their upper body backwards when the swing is at the bottom of the arc and moving forward. After gaining height, the person should start leaning back earlier, when the swing is at the furthest part of the backswing (*Physical Review E*, doi.org/j5tv).

To see how their model stacked up against real-world activity, they filmed 10 students swinging in the lab. This showed that what the students were doing matched the rules derived from the mathematical model.

Hirata says that this leads to more questions: "How do the swingers shift their body so well? It is hard to believe that they are moving intentionally because they must adjust their body as quickly as in 10 milliseconds."

The researchers' current hypothesis is that swingers are subconsciously reacting to some centrifugal-like force that is pushing them back. They want to test this idea on swings in virtual reality where those forces shouldn't exist. ▮

Environment

Emissions from electricity generation may have peaked

Madeleine Cuff

CFOTO/FUTURE PUBLISHING VIA GETTY IMAGES

Rewewable energy in Jiangsu province in China

CARBON emissions from global electricity generation may have peaked and are expected to start declining in the coming years, in a sign the power sector could have reached a tipping point in its transition to clean power.

Electricity emissions grew by 1.3 per cent in 2022 to hit a record high, fuelled by a small increase in coal use to meet growing electricity demand after the covid-19 lockdowns.

But 2022 will probably be the last year the global power sector will log growth in greenhouse gas emissions, according to energy think tank Ember, which claims the sector has hit a historic turning point in the shift to clean sources of power.

In a report that draws on 2022 data from 78 countries covering 93 per cent of global electricity demand, Ember says record deployments of renewable power last year pushed wind and solar to a new high of 12 per cent of electricity generation, up from 10 per cent in 2021.

Green power met 80 per cent of the rise in electricity demand as economies opened up after covid-19 lockdowns, with coal generation increasing by just 1.1 per cent during 2022.

The pace of growth in clean power will accelerate from 2023, according to the Ember report, as developers take advantage of falling technology costs and favourable government policies to roll out more cheap, green electricity generation.

80%

Proportion of the increase in electricity demand in 2022 met by renewable power

Strong growth in renewable deployment, coupled with a small decrease in fossil fuel generation, will see power sector emissions plateau or fall next year, it predicts.

"In this decisive decade for the climate, it is the beginning of the end of the fossil age," lead author Małgorzata Wiatros-Motyka said in a statement.

Alfonso Martinez-Felipe at the University of Aberdeen, UK, says the prediction is "feasible".

But James Glynn at Columbia University, New York, says it will take another year or two for the trend in emissions to become clear. "It is possible that 2022 may have been the peak year of global power sector emissions, but we won't know until 2024 or 2025," he says.

The global electricity sector needs to be one of the first sectors to decarbonise to keep the world on track for net-zero emissions by mid-century, a pathway in line with limiting global warming to 1.5°C.

According to the International Energy Agency, the sector must be net zero globally by 2040 to keep pace with this timeline.

But despite Ember's predictions that power sector emissions may have peaked, questions remain over whether they will fall fast enough to meet the agency's deadline.

Charlie Donovan at Impax Asset Management says that most people in the energy sector agree that power sector emissions have peaked or will do so imminently, because commercial and political forces now favour a global transition to low-carbon power.

"Everybody's projections are for a peak in emissions from the power sector," he says. "The structural drivers are there."

But he warns that a recent collapse in fossil fuel prices could push up the use of coal and gas for electricity generation in the short term. This could mean emissions persist this decade, rather than start to fall. "I do think we could stay at a plateau for a lot longer than some of the long-term fundamental drivers would suggest," he says. ▮

Archaeology

Bone fragment reveals humans wore leather clothes 39,000 years ago

Alison George

AN ANALYSIS of a 39,600-year-old bone with strange indentations indicates it was used as a punch board for making holes in leather. This hints how *Homo sapiens* in Europe made clothes to help them survive the cold.

"We do not have much information about clothes because they're perishable. They are an early technology we're in the dark about," says Luc Doyon at the University of Bordeaux, France.

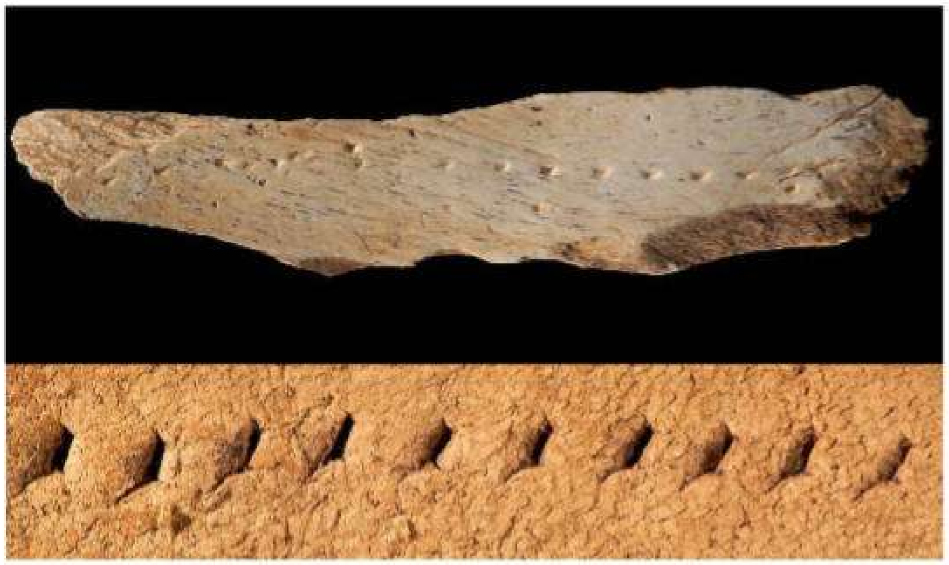
The bone, from the hip of a large mammal like a bison, was found at a site called Terrasses de la Riera dels Canyars near Barcelona, Spain. It has 28 puncture marks on its flat surface, including a linear sequence of 10 holes about 5 millimetres apart, with the others in more random positions.

This pattern was intriguing, says Doyon, because it didn't seem to be a decoration or to represent a counting tally – the usual explanations for patterns of lines or dots on prehistoric objects. Microscopic analysis revealed that the line of 10 indents was made by one tool and the others were made at other times with different tools.

Doyon and his colleagues used an approach called experimental archaeology, in which you try out ancient tools to see how marks were made. "We're attempting to replicate the gestures that were used by prehistoric people to produce a specific modification on the bone," says Doyon.

The only way they found to recreate the type of indents on the bone was to knock a chisel-like stone tool called a burin through a thick hide, a technique called indirect percussion. The same method is still used by cobblers and in traditional societies to pierce leather.

This bone carries marks that were probably made by puncturing leather



F. D'ERRICO AND L. DOYON

The most likely explanation for the indents is that they were made when making or repairing leather items, say the researchers (*Science Advances*, doi.org/gr4xkj). After punching a hole in the animal hide, a thread could be pushed through the material with a pointed tool to make a tight seam, says Doyon.

"It's a very significant discovery," says Ian Gilligan at the University of Sydney, Australia. "We have no direct evidence for clothes in the Pleistocene, so finding any indirect evidence is valuable. The oldest surviving fragments of cloth in the world date from around 10,000 years ago."

This also helps solve a mystery about when people started making fitted clothes. *Homo sapiens* reached Europe some 42,000 years ago, yet eyed needles haven't been found in this region from earlier than around 26,000 years ago and these aren't strong enough to repeatedly puncture leather.

"The location and date are interesting: southern Europe nearly 40,000 years ago," says Gilligan. "That's quite soon after the arrival of *Homo sapiens*, during some rapid cold swings in the climate. It's when and where we'd expect our ancestors to need good clothes for protection."

Doyon and his colleagues claim the punch board marks a crucial cultural adaptation that helped modern humans expand to new regions. ▮

Biophysics

How anacondas perform a weird, twisting lunge

YELLOW anacondas are able to leap into an S-shape to escape danger. But, only those that are light and muscular enough can actually do it.

Many snakes that live in sandy environments can sidewind, rippling their bodies while also partially lifting off the ground. Anacondas, which typically live near water, aren't normally considered to be in this group and have only been captured on film doing something like sidewinding once, in 2014.

Nicholas Charles at Harvard University and his colleagues have now found when and how yellow anacondas (*Eunectes notaeus*) are able to perform lunges similar to sidewinding. In the lab, they studied how 10 yellow anacondas of different ages and sizes moved when scared, and noticed that some could quickly jump away in a move the researchers dubbed the S-start.

The snake would keep its middle portion still and flat to the ground, but raise its head and tail. This produced a ripple along the snake's body, causing it to jump sideways (arXiv, doi.org/j5tt). The two oldest and largest anacondas never moved this way, while three newborns and five juveniles did.

Computer simulations that took into account the gravity and friction the snake must overcome showed that the ratio of a snake's weight to the strength of its muscles must be just right for the S-start to be possible. Simulated snakes that were too heavy unravelled into a flat line instead of moving, while those that were too light flailed in place. When a snake weighed 20 times the torque that its muscles could produce, it could S-start, but at 40 times the torque, it couldn't. This explained why adult anacondas couldn't do the S-start, as older snakes have less muscle and more bone mass, so they are too heavy.

"When scared, some anacondas could quickly jump away in a move dubbed the S-start"

The team suggests that the S-start may have led to the evolution of sidewinding. Jessica Tingle at the University of Akron in Ohio says that more detailed studies are needed to establish that. ▮

Karmela Padavic-Callaghan

New Scientist Events

New Scientist Live

THE WORLD'S GREATEST FESTIVAL OF IDEAS AND DISCOVERIES *RETURNS...*

7 – 8 OCTOBER | SCHOOLS' DAY 9 OCTOBER
EXCEL LONDON AND ONLINE

Find out more

newscientist.com/nslpa

FARMERS WEEKLY
King's College London
FEATURE PARTNERS

Technicians We make the difference
SCHOOLS' DAY PARTNER

Medical Research Foundation
CHARITY PARTNER

i
MEDIA PARTNER

Technology

Robot learns how to avoid butter fingers

A SOFT robotic hand can pick up objects and adjust the way it holds them when they start to slip.

Many such devices are good at picking up things, but adjusting to cope with items that slip can be challenging. Thomas Thuruthel at University College London and his team have made a soft robot hand that can keep a shifting object in its grasp with only wrist motions.

The hand is made of moulded silicone with flexible pressure sensors on the palm and fingers. The wrist is the only part of the hand that can move. The whole device is linked to an AI system.

This software learned to recognise when an object was beginning to slip, manipulating the robot wrist to avoid a drop 79 per cent of the time (*Advanced Intelligent Systems*, doi.org/j5w7).
Karmela Padavic-Callaghan

Zoology

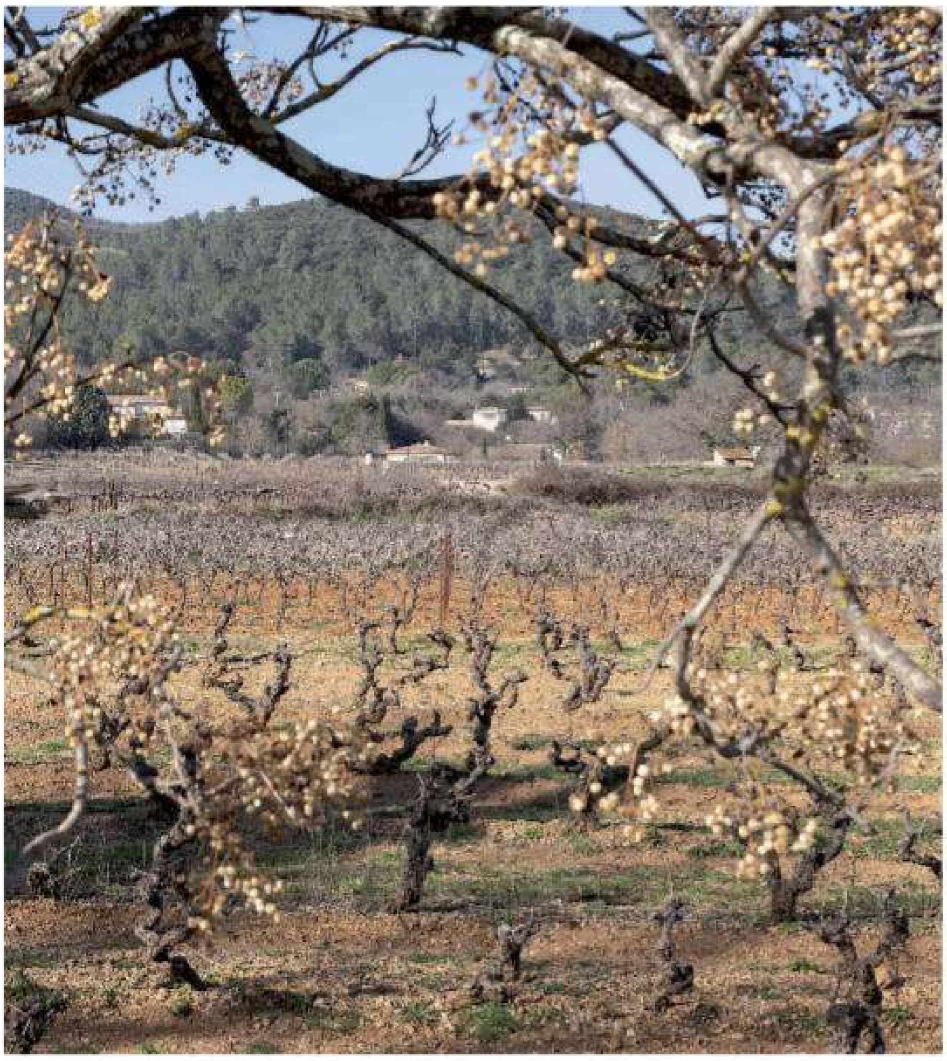
Seahorse's power move is explained

SEAHORSES have an unusually potent way of gulping down prey, and now we know how it is done.

The fastest animal movements, such as the punch of a mantis shrimp, are powered by spring mechanisms. Like drawing a crossbow, muscles pull tendons into a latched position before releasing the tension.

Researchers already knew that seahorses had an elastic tendon on the back of their head that pushes their snout upward while feeding, but Roi Holzman at Tel Aviv University in Israel and his team found that this wouldn't account for the shear sucking power the small fish can generate.

However, they then discovered a second tendon, below the chin, that accounts for the extra oomph (*Proceedings of the Royal Society B: Biological Sciences*, doi.org/gr4stc).
Corryn Wetzel


JEREMY SUYKER/BLOOMBERG VIA GETTY IMAGES

Environment

Europe to be a hotspot for droughts that take hold fast

CLIMATE change is leading to more frequent "flash droughts", which take just a few weeks to materialise and can shock ecosystems.

Almost three-quarters of the world has seen a rise in these rapid dry spells over the past 64 years, according to modelling by Xing Yuan at Nanjing University of Information Science and Technology in China and his colleagues.

As climate change advances, almost all the world's landmasses will be affected by more frequent flash droughts that take hold faster, with Europe a particular hotspot, says Yuan. These events usually last for between 30 and 45 days, whereas slow-onset droughts tend to take several weeks or months to appear and last for 40 to 60 days. The increase in flash versions is due to the warming climate, he says. Higher air temperatures also mean water evaporates from soil more quickly, bringing on a drought state sooner, he adds.

Although the work suggests that the incidence of flash droughts is increasing significantly around the world, it doesn't provide data demonstrating the pace of change. But Yuan says the proportion of dry periods that qualify as flash droughts could increase by 15 to 20 per cent between 2050 and 2100, compared with between 1950 and 2000, depending on how quickly the climate warms (*Science*, doi.org/gr4xm3).

As Yuan points out, existing drought monitoring systems aren't designed to spot incoming flash droughts, leaving very little warning, for example for growers of grape vines in France (pictured). Wildlife and plant life may also struggle to adapt to rapid-onset drought, he warns. **Madeleine Cuff**

Really brief

GEORGE GRALL/ALAMY

Why orchid bees make perfume

The perfume that male orchid bees create by collecting scents from flowers is designed to win over females. A study with perfume-less male bees that had just emerged from pupae showed that females only mated with those that researchers gave a splash of perfume to (*Current Biology*, doi.org/j5wq).

Sperm test guides fertility treatment

A test that shows if sperm are capable of puncturing, and ultimately fertilising, an egg could help people choose the type of fertility treatment that offers them the best chance of success. The test indicates whether someone has dysfunctional variants of *Catsper* genes that can cause infertility (medRxiv, doi.org/j5w2).

Table salt swap cuts blood pressure

Replacing regular table salt with a potassium-enriched substitute can reduce blood pressure in people who are over 55. This is according to a study of about 1600 people living in care homes. The reduction should cut the risk of cardiovascular events, such as heart attacks and stroke (*Nature Medicine*, doi.org/j5ws).

New Scientist Discovery Tours

Ancient caves, human origins: Northern Spain

13 June and 29 August 2023 | 7 days From £2999

Discover some of the world's oldest known cave paintings in this idyllic part of Spain. Travel back 40,000 years to explore how our ancestors lived, played and worked. Experience the wonders of several renowned caves full of art from before the dawn of civilisation including El Castillo, Las Monedas, La Peña Cave, El Pindal and Tito Bustillo in small groups by torchlight. Plus visit the stunning replica of Altamira, the Museo de Evolución Humana and the Archaeological Museum of Santander.

Accompanied by *New Scientist*'s Emily Wilson and Kate Douglas, who will give insight on the dawn of human culture and civilisation. Plus with local archaeological experts and cave custodians, you'll enjoy specialist talks and walking seminars along the way.

Highlights

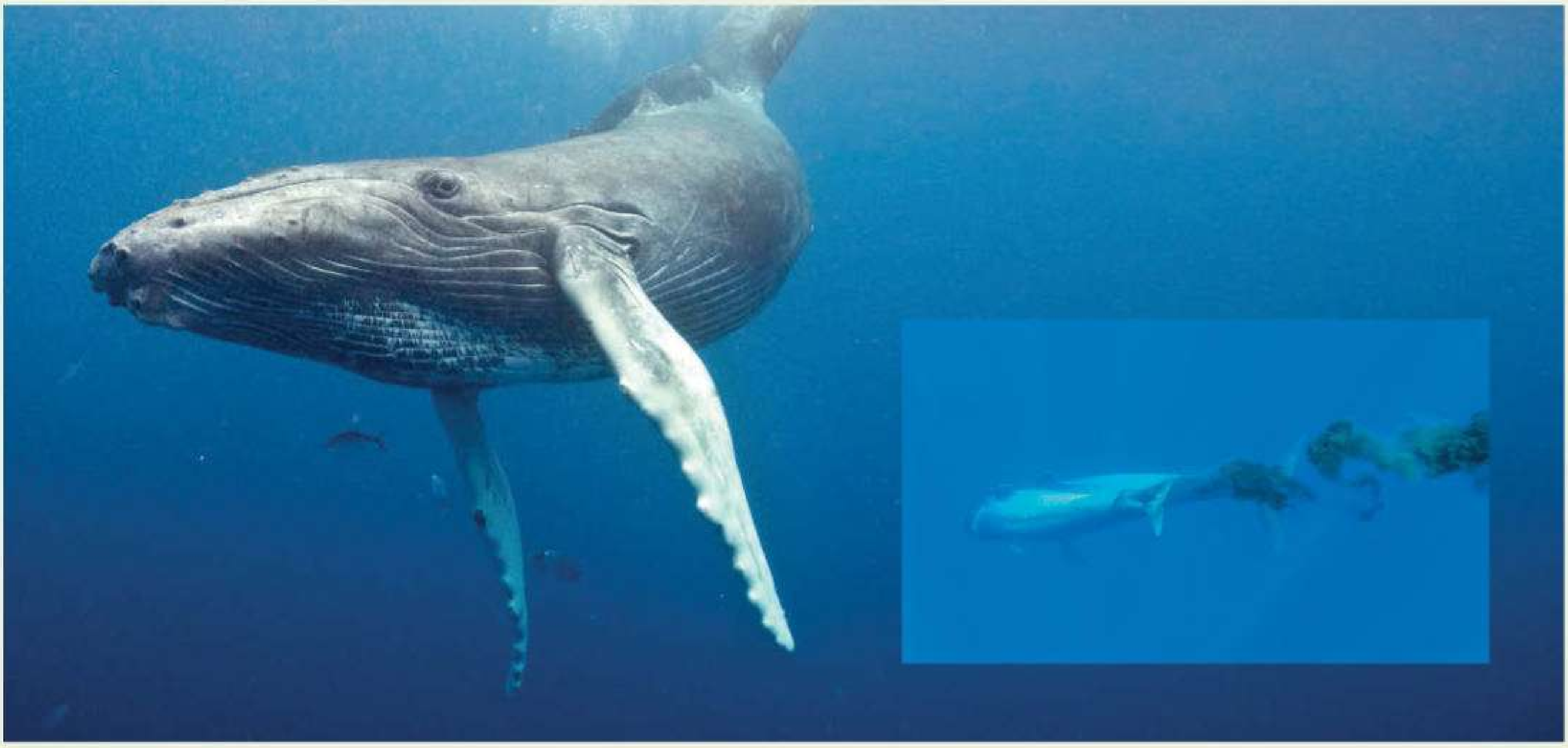
- Travel to Burgos to visit the Museo de Evolución Humana, where you will learn about the archaeological and palaeontological history of the surrounding Atapuerca mountains, the many stages of human evolution and the story of Charles Darwin's exploration around the world that led to the theory of evolution.
- You will visit the caves of El Pindal, containing the first palaeolithic cave paintings discovered in the region, the most notable of which is a woolly mammoth.
- In the charming coastal town of Ribadesella, you will visit the Tito Bustillo cave before traveling south to the Cave El Buxu. Discovered in 1916, this cave houses both paintings and engravings.
- In Candamos, you will visit La Peña Cave, the largest cave with rooms leading off it, this cave contains several different panels of art dating back 18,000 years and covering several species.
- Visit El Castillo, home to one of the oldest known cave paintings, dated as more than 40,000 years old. Located in Puente Viesgo, it is situated in a limestone hill, which hides an intricate labyrinth of caves frequented by prehistoric humans.
- You will travel east to Santander to visit the Archaeological Museum, where you will see an array of artifacts, interactive guides and vivid interpretations of stone age life.
- Spend time at the world-famous Guggenheim Museum, viewing the modern and contemporary art in this stunning Frank-Gehry-designed building, an awe-inspiring monument to design modernism.

To book call +44 (0) 203 3089 917 (Office: Mon-Fri 9am to 5:30pm, Sat 10am to 4:30pm)
Or email newscientist@intrepidtravel.com
newscientist.com/tours

In partnership with Intrepid Travel

Intrepid
ABTA
Travel with confidence
ABTA No.88888

Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **Whale and Dolphin Conservation**



Become a Climate Giant Hero – save the whale, save the world

■ We know a lot about how trees and bees help fight climate and biodiversity breakdown, but not as much about how whales do.

■ We know that whales act as giant 'ocean gardeners' by diving deep to feed, and coming to the surface to breathe and poo, circulating a huge amount of nutrients. Whale poo is a brilliant fertiliser for microscopic plant-like organisms called phytoplankton, which remove millions of tonnes of carbon from the atmosphere and produce massive amounts of oxygen.

■ We know that a healthy planet needs a healthy ocean and that means more whales. But humans have slaughtered up to 99% of some whale populations, and only 1% of global climate finance goes towards ocean projects. This needs to change now. We need to save the whale to save the world.

In order to convince policymakers to act, we need more evidence and quickly. That's why Whale and Dolphin Conservation are funding incredible research projects, led by world-leading scientists, into the climate role of whales and dolphins. For the first time ever, we could understand the daily role of whales and dolphins on the ocean's ability to absorb carbon through the AnimOcean project, using the power of supercomputer modelling to bring together data from research projects across the world. We'll quantify the value of whales and dolphins in tackling climate change, giving us the evidence we need to influence governments to change conservation policies across the world.

How can you help?

The AnimOcean project is the first of many initiatives that could be funded through our Climate Giants Research Fund, WDC's biggest and most ambitious project ever. It will be a game-changer for ocean conservation, and we need your support to help make it happen.

A donation from you today will fund research projects to plug the gaps in our knowledge to convince policymakers to dramatically increase the share of climate funding that focuses on the ocean. These results will inform global conservation to restore whale and dolphin populations to the numbers they were before decades of whale hunting decimated their numbers and pushed many populations to the point of extinction. Find out more at whales.org/signalboost

Do you need your signal boosted?

If you are a charitable organisation working in STEM, science, medicine, technology or conservation, and would like to find out more about this project contact Jacqui McCarron on jacqui.mccarron@newscientist.com

Views

The columnist
Penny Sarchet muses on why orchids are so diverse p28

Aperture
Peruse stunning examples of world photography p30

Letters
Maybe our big bang was just the best of the bunch p32

Culture
Will neural tech lead to the end of privacy? p34

Culture columnist
Bethan Ackerley sees double in new *Dead Ringers* TV show p36

Comment AI special report

Facing AI extinction

Why do many of today's artificial intelligence researchers dismiss the potential risks to humanity, asks **David Krueger**

SIMONE ROTELLA

IN A recent White House press conference, press secretary Karine Jean-Pierre couldn't suppress her laughter at the question: Is it "crazy" to worry that "literally everyone on Earth will die" due to artificial intelligence? Unfortunately, the answer is no.

While AI pioneers such as Alan Turing cautioned that we should expect "machines to take control", many contemporary researchers downplay this concern. In an era of unprecedented growth in AI abilities, why aren't more experts weighing in?

Before the deep-learning revolution in 2012, I didn't think human-level AI would emerge in my lifetime. I was familiar with arguments that AI systems would insatiably seek power and resist shutdown – an obvious threat to humanity if it were to occur. But I also figured researchers must have good reasons not to be worried about human extinction risk (x-risk) from AI.

Yet after 10 years in the field, I believe the main reasons are actually cultural and historical. By 2012, after several hype cycles that didn't pan out, most AI researchers had stopped asking "what if we succeed at replicating human intelligence?", narrowing their ambitions to specific tasks like autonomous driving.

When concerns resurfaced outside their community, researchers were too quick to dismiss outsiders as ignorant and their worries as science fiction. But in my experience, AI researchers are themselves often ignorant of arguments for AI x-risk.

One basic argument is by analogy: humans' cognitive abilities allowed us to outcompete other species for resources, leading to many extinctions. AI systems could likewise deprive us of the resources we need for our survival. Less abstractly, AI could displace humans economically and, through its powers of manipulation, politically.

But wouldn't it be humans wielding AIs as tools who end up in control? Not necessarily. Many people might choose to deploy a system with a 99 per cent chance of making them phenomenally rich and powerful, even if it had a 1 per cent chance of escaping their control and killing everyone.

Because no safe experiment can definitively tell us whether an AI system will actually kill everyone, such concerns are often dismissed as unscientific. But this isn't an excuse for ignoring the risk. It just means society needs to reason about it in the same way as other complex social issues. Researchers also emphasise the difficulty of predicting when AI might surpass human intelligence, but this is an argument for caution, not complacency.

Attitudes are changing, but not quickly enough. AI x-risk is admittedly more speculative than important social issues with present-day AI, like bias and misinformation, but the basic solution is the same: regulation. A robust public discussion is long overdue. By refusing to engage, some AI researchers are neglecting ethical responsibilities and betraying public trust.

Big tech sponsors AI ethics research when it doesn't hurt the bottom line. But it is also lobbying to exclude general-purpose AI from EU regulation. Concerned researchers recently called for a pause on developing bigger AI models to allow society to catch up. Critics say this isn't politically realistic, but problems like AI x-risk won't go away just because they are politically inconvenient.

This brings us to the ugliest reason researchers may dismiss AI x-risk: funding. Essentially every AI researcher (myself included) has received funding from big tech. At some point, society may stop believing reassurances from people with such strong conflicts of interest and conclude, as I have, that their dismissal betrays wishful thinking rather than good counterarguments. ▮

For more on AI, see pages 12 and 46

David Krueger is an assistant professor in machine learning at the University of Cambridge

Wild Wild Life

Blooming marvellous Orchids seem unique in how they inspire such a devoted following, but why are there so many species of these much-loved plants, wonders **Penny Sarchet**

Penny Sarchet is *New Scientist*'s news and digital director. She is a former plant scientist and a lifelong birdwatcher. You can sign up to her free monthly newsletter at newscientist.com/wildwildlife

Penny's week

What I'm reading

The Tree in My Garden, *Kate Bradbury's guide to choosing and planting the right tree for you and for wildlife.*

What I'm watching

Unsurprisingly, Wild Isles, *the BBC's latest wildlife documentary. The Eurasian hobbies catching dragonflies in flight were my favourite.*

What I'm working on

A feature about rediscovering long-lost species. Look out for it next month!

Up next week:
Chanda Prescod-Weinstein

THE announcement of a newly recognised orchid species in Japan prompted discussion among our UK news team recently. *Spiranthes hachijoensis* is undoubtedly beautiful, and it is always surprising to hear of new species in well-studied countries. But I couldn't help being slightly cynical about this one, which is very similar to another known species, but not as hairy.

My cynicism has its roots in the great divide between lumpers and splitters: the tendency among taxonomists and natural historians to prefer either to classify similar organisms as a single species or to split them up into multiple distinct ones. There are good arguments in favour of each approach, but the orchid family, which may be the largest plant family in the world, provides ample opportunity for splitting to run wild. For example, depending on your philosophy, there could be as many as 529 species of orchid in Europe – or only 102.

Nevertheless, Orchidaceae is an extraordinary family and may account for a tenth of all seed-producing plants. It boasts a staggering number of species, at around 25,000, and includes some of the most beautiful, startling and cunning flowers in existence. One member of this family is *Vanilla planifolia*, the source of vanilla, one of the world's favourite flavourings.

The huge number of orchid species isn't just the work of splitters, it also reflects an incredible range of different forms. This can feel surprising – we tend to think of orchids as delicate and rare, but they are also diverse and widespread. Why is this the case?

One person to ask this question was orchidologist Calaway Dodson, who, in 2003, tackled the issue of why there are so many orchid species in Ecuador in particular. He noted that Ecuador is the smallest country in the Andes, but that more than 3700 species of orchid had been recorded there, and proposed a number of features of orchids that may contribute to their ability to rapidly diversify into new species. Seeds were one of these: orchids produce a very large number of tiny, wind-disseminated seeds, providing plenty of scope to spread large distances and grow in new places.

Some of Dodson's other suggestions were later supported by a 2015 study that used genetics and fossils to probe orchids' family tree and evolutionary history and to identify physical innovations that coincided with times of significant diversification. One of these was epiphytism, the tendency of many orchids to grow on trees. It could be that the diversity of habitats provided by tree branches and holes encouraged the evolution of new species that were well adapted to these common and under-exploited surfaces.

> **"Orchidaceae boasts a staggering number of species, including some of the most beautiful flowers in existence"**

Another of Dodson's suggestions that was borne out by the analysis was deceit pollination, a practice employed by a large number of orchids where they mimic the mate of their specific pollinator, both in appearance and through the release of compounds that make them smell like a particular bee, for example. This is a highly effective way of ensuring pollination, but it probably works best when mimics are rare so that pollinators aren't deceived too often. It is possible that this therefore drives the evolution of new orchid species that target other pollinator species, to avoid them catching on. It seems to work – there are several hundred species of the *Ophrys* genus of Mediterranean bee orchids.

Orchids don't stop there. Several other factors may contribute to their outstanding ability to speciate, including having CAM metabolism, a form of photosynthesis that enables plants to accumulate carbon dioxide at night and shut their pores during the day, which is beneficial in dry environments. We can probably also thank the evolution of pollinia, highly specialised little packets of pollen that orchids position very precisely on specific pollinators to ensure targeted pollination.

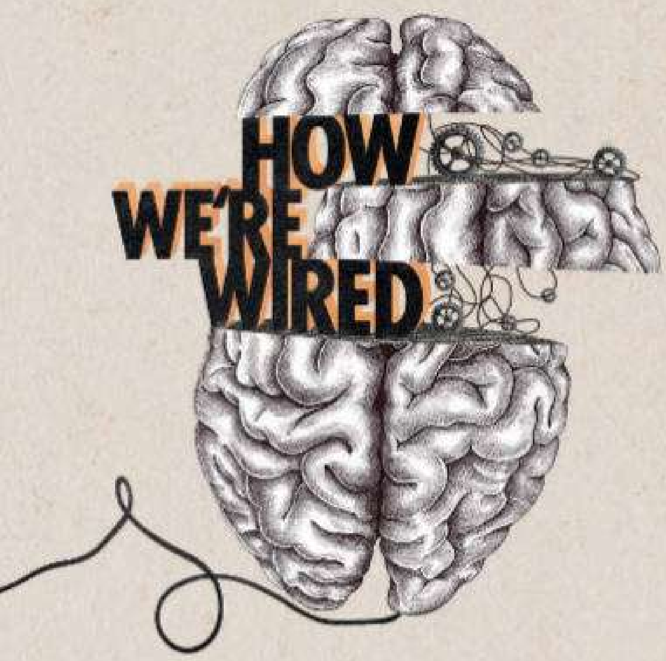
The end results of all this are some of the world's most loved flowers. Orchids seem unique in how they inspire such a devoted following: there are more than 40 orchid societies in the UK alone.

The thrill of seeing orchids in the wild is very special indeed and you don't need to travel to the tropics to see them – there are about 200 species in North America and around 50 in the UK. My first were bee orchids in Portugal's Algarve region, but the common spotted orchids that I subsequently saw growing at Loch Lomond in the UK, surrounded by frogs, really spring to mind. In temperate northern hemisphere countries, orchids are beginning to flower now. Do get out to see them if you can, but be careful to stick to paths, as it is easy to crush orchids that haven't flowered yet without ever realising.

OWN YOUR MIND BUSINESS

Discover what makes you tick with How We're Wired, a brand new podcast that looks at what happens inside your brain – from before you were born through to death.

Presented by anthropologist Dr Anna Machin, this series features real life stories, expert analysis, the latest research and at-home experiments that will open your eyes to the most fascinating organ in the human body.



fondation
bertarelli
fondation-bertarelli.org

Search for **'How We're Wired'** and subscribe wherever you get your podcasts.

Apple Podcasts Google Podcasts Spotify

SRIRAM MURALI, INDIA, 3RD PLACE, PROFESSIONAL COMPETITION, WILDLIFE & NATURE

ADALBERT MOJRZISCH, GERMANY, 2ND PLACE, PROFESSIONAL COMPETITION, WILDLIFE & NATURE

COREY ARNOLD, US, WINNER, PROFESSIONAL COMPETITION, WILDLIFE & NATURE

GEORGE STEINMETZ, US, SHORTLIST, PROFESSIONAL COMPETITION, LANDSCAPE

CESAR DEZFULI, SPAIN, SHORTLIST, PRO COMPETITION, LANDSCAPE

FABIO BUCCIARELLI, ITALY, 3RD PLACE, PRO COMPETITION, LANDSCAPE

World on show

2023 Sony World Photography Awards

THIS dynamic spread of images shows some of the entries to the professional competition of the 2023 Sony World Photography Awards, which were held on 13 April.

Among the finalists in the Wildlife & Nature category was Sriram Murali for his shot of the Anamalai Tiger Reserve near his hometown of Pollachi, India (top left). Though the area is a hotspot for bigger wildlife, it is the millions of fireflies that steal the show after dark, says Murali, who created the image by stacking several photos of this glowing congregation.

To its right is another finalist entry, by Adalbert Mojrzisch, displaying the remarkable colours of a hard-bodied tick revealed by the magnification and polarised backlight of a microscope. The photo at bottom left, of a coyote framed by city lights, is part of Corey Arnold's series *Cities Gone Wild*, which won the Wildlife & Nature category.

In the Landscape category, the shortlisted image at top right by Cesar Dezfuli shows a soccer field covered in ash in La Palma, Spain – the aftermath of a 85-day volcanic eruption that started in September 2021. Beneath, this photo is a shot of a submerged car in Mayendit village in South Sudan, taken by finalist Fabio Bucciarelli, showing the result of extreme floods.

Finally, George Steinmetz was shortlisted for his drone shot of an organic garden at the Château de Villandry, France (bottom right), part of his series exploring the challenge of feeding a booming population.

Selected images from the awards are on show at Somerset House, London, until 1 May. ▮

Gege Li

Editor's pick

Maybe our big bang was just the best of the bunch

1 April, p 46

From Mike Lawrence, Ipswich, Suffolk, UK

You report the hunt for possible black holes that predate the big bang, which could be evidence for repeated big bangs and a type of cyclical universe. Perhaps our own big bang is just one of many in a larger cosmos, but has been particularly successful in balancing inflation and gravitational collapse, expanding for so long that it now constitutes the greatest fraction of everything. Some of the black holes we observe could be failed big bangs, which have long ago collapsed back onto themselves.

Our dominant big bang would mask signals from other such events and give time for the rise of life forms able to consider such ideas and wonder at the delicate balance that has allowed their existence.

Prepare yourselves for a serving of quantum gravy

8 April, p 36

From Roger Morgan, Presteigne, Powys, UK

Thank you for the guide to the mysteries of the quantum realm.

The chef at my local garden centre restaurant and I often deliberate on such matters across the counter, and last week we were discussing the relationship between quantum uncertainty and the basis of free will. The next server along the counter waited patiently for us to reach agreement that the universe consists of waves, particles, forces and uncertainty, then, keen to return us to the realities of lunch, said: "And gravy over everything?"

Perhaps our predecessors would have referred to this as the "ether", from which mysterious entities could manifest themselves. Even in this piece, Jon Cartwright writes of "some residual photon-ness everywhere". Particles appear when wave fields get excited, just as lumps appear in gravy.

Given the fascinating etymology of such terms as quarks and gluons, can I put in a bid for "gravy" as the next quantum term for fields that cover everything?

From Alastair Cardno, Burley in Wharfedale, West Yorkshire, UK

Many thanks for the really clear guide to the quantum world. It was helpful to see all the key aspects and relationships together. Despite being a regular reader, some things were new to me, such as that gluons travel at the speed of light. The section on how forces work was also very useful. Plus, not a quantum cat in sight!

Another way to make things just right for life

25 March, p 38

From Spencer Weart, Hastings-on-Hudson, New York, US

Thomas Hertog recalls his and Stephen Hawking's subtle explanation for why physical laws and parameters are "just right for life", positing that they initially varied randomly over time. There is, however, a simpler explanation: that physics varies randomly over space. To be sure, the variations must be gradual over enormous distances. But in a sufficiently large or infinite universe, there will be regions where all the laws happen to be just right. We are, evidently, in such a region.

Only the young ones can save us now

25 March, p 27

From Geoff Harding, Sydney, Australia

A sustainable population without overconsumption has been advocated for decades, but with minimal effect. With significant pressure now exerted through the IPCC and environmentalists to change destructive lifestyles and industries, there is a chance that warnings may finally take effect. Tragically, it is likely that few people in high-income countries over 40, with set lifestyles and high consumption, will respond.

However, Greta Thunberg and other activists have shown it is possible to educate and motivate millions of young people to campaign for change, think carefully and moderate their lifestyles. Education of the world's youth is thus the key, and perhaps the only hope.

On the drive to get us to ditch our gas boilers

8 April, p 11

From David Le Maistre, Horley, Surrey, UK

I question the UK government pushing for us to ditch modern gas boilers to heat homes before the power system is truly green. The efficiency of my gas boiler is about 95 per cent, whereas if I use grid electricity to heat my home, the efficiency of a gas turbine to generate it is around 50 per cent.

Even allowing for current usage of renewables, my carbon footprint seems lower by staying with gas.

Less is more when it comes to the sweetness of cakes

1 April, p 27

From Martin Whittle, Sheffield, South Yorkshire, UK

I am unconvinced that biscuits and cakes made with a 2:1 ratio of sugar to fat are naturally "irresistible". For years, we have made cakes at home using half or less than half the sugar recommended by standard recipes. Other flavours aren't overpowered and the resulting taste is more complex and interesting. Shop-bought cakes now taste sickly and I normally avoid them in cafes because they are so sweet as to spoil my coffee.

I would suggest that the real reason shop-bought cakes contain so much sugar is to increase shelf life, thereby making more bucks for the shareholders.

Yet more explanations for the strange cave hand art

18 March p 38

From Susan Goodman, Jerusalem, Israel

The claim that hand stencils in Gargas cave, France, show a sign language is very unlikely – there is a more plausible explanation.

One of the illustrations includes the anatomically tricky gesture of an extended little finger and an extended adjacent ring finger, while the next two fingers are folded down and the thumb is extended. Try it. And if you were signing, wouldn't the appearance and disappearance of your thumb, not seen in the cave stencils, be a strong visual signal? Perhaps these are actually severed hands, with and without severed fingers. Body parts have been gathered as war trophies and as religious relics at other times throughout history.

From Kaisa Saarenmaa, Helsinki, Finland

The jury is still out concerning the meaning of the ancient hand stencils with missing or stunted fingers found in caves. I would like to suggest a new interpretation.

Previously, it has been shown that cave art is usually located in the most resonant parts of the cave. Could these stencils be an early form of musical notation? I believe the stencils exhibit the different techniques for playing some kind of flute. The missing digits aren't mutilated fingers, but indicate whether to lift or put down a finger on an open hole while playing the instrument. ▮

Want to get in touch?

Send letters to letters@newscientist.com; see terms at newscientist.com/letters

Letters sent to New Scientist, 9 Derry Street, London, W8 5HY will be delayed

New Scientist
Jobs

Recruit the brightest minds in science

At New Scientist Jobs, we can help you to reach, engage and attract the highest-quality job applicants, wherever they are. Over 157,000 people* come to our site every month looking for their dream job and ideal employer – which could be you!

newscientistjobs.com

*Source: Google Analysis Jan-Dec 2021

Neuro nightmares ahead

How will we find a way through the new minefield of brain tracking and hacking? **Simon Ings** reads an excellent, if deeply troubling, guide

Book

The Battle for Your Brain

Nita Farahany

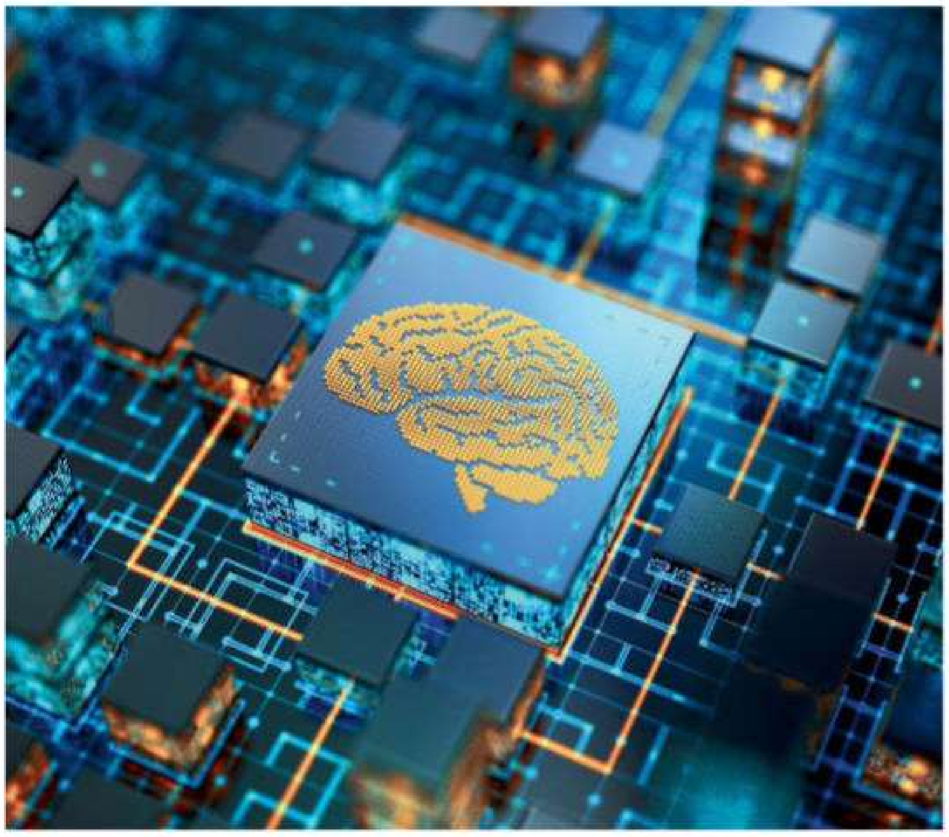
St Martin's Press

ETHICIST and lawyer Nita Farahany is no stranger to neurological intervention. She has sought relief from her chronic migraines in "triptans, anti-seizure drugs, antidepressants, brain enhancers, and brain diminishers". She has had "neurotoxins injected into my head, my temples, my neck, and my shoulders; undergone electrical stimulation, transcranial direct current stimulation, MRIs, EEGs, fMRIs, and more".

Few know better than Farahany what neurotech can do for people's betterment, and this lends weight to *The Battle for Your Brain: Defending the right to think freely in the age of neurotechnology*. Her book is a sombre, troubling, yet essential account of a field whose speed of expansion alone should give us pause. Here we meet Myontec, Athos, Delsys and Noraxon, firms already offering insights to athletes and sports therapists that are generated by electromyography (EMG), a way to assess the health of muscles and the nerve cells controlling them.

Then there is the NeuroNode from Control Bionics, a wearable EMG device for people with degenerative neurological disorders that enables them to control a computer, tablet or motorised device. Or Neurable, a firm that promises "the mind unlocked" with its "smart headphones for smarter focus".

That is before we even turn to the fast-growing interest in implantable devices. Synchron, Blackrock Neurotech and Elon Musk's Neuralink all have brain-computer interfaces in advanced stages of development.



BLACKJACK3D/ISTOCKPHOTO/GETTY IMAGES

Will brain-sensing devices improve life or allow our minds to be monitored?

Setting aside the medical applications for a moment, Farahany is concerned that neurotech we used to use only for playing video games, meditating or improving our focus has opened the way to a future of brain transparency in which, she warns, "scientists, doctors, governments, and companies may peer into our brains and minds at will".

> **"There are now earbuds staff can wear said to monitor brain activity to show their emotional and cognitive state"**

Think it can't be done? A team led by Dawn Song, a computer scientist at the University of California, Berkeley, reported an experiment in which people used a neural interface to control a video game. As they played, the researchers inserted subliminal images into the game and watched for unconscious recognition signals. This netted them one player's home address – and the access code of their credit card.

Now, we learn from Farahany, Massachusetts-based firm Brainwave Science is selling software called iCognative, which it says can analyse EEG signals and tell if an individual knows something about a crime, act of terrorism, piece of intel and so on. Or, at least, suspects are shown pictures related to crimes and can't help but recognise whatever they happen to recognise.

This technique is as popular with governments (such as those in Bangladesh, India and Australia) as it is derided by many scientists.

Even more worrying, given the scale of home working in the wake of covid-19, are efforts to use neurotech to monitor remote employees. Some programs already take regular screenshots of their work, record keystrokes and web usage and photograph them at (or not at) their desks. San Francisco bioinformatics company Emotiv now offers to help manage your employees' attention with its MN8 earbuds. These can indeed be used to listen to music or participate in conference calls. And with just two electrodes, one in each ear, the device is said to be able to record emotional and cognitive functions of staff in real time.

After surveying Farahany's dismal catalogue, it will come as no surprise if neurotech does become a requirement in modern workplaces: no earbuds, no job. This sort of thing has happened many times already in the past.

Vladimir Lenin complained in 1912 of factory workers paid more to adopt methods that quadrupled productivity. "As soon as workers get used to the new system their pay is cut to the former level," Lenin wrote. The capitalist "attains an enormous profit" while the workers "toil four times as hard as before and wear down their nerves and muscles four times as fast".

Ironically enough, six years later, Lenin approved funding for a research institute based on the principles of Frederick Winslow Taylor. Taylor pioneered "scientific management", which aimed to up productivity by applying science to the way we work.

Farahany offers no quick fixes for what could be the 21st-century equivalent, the high-tech assaults on the mind – "the one place of solace to which we could safely and privately retreat", as she puts it. I was left wondering what to be more afraid of: the neural devices themselves, or the glee with which the powerful seize upon them. ▮

Simon Ings is a writer based in London

A world in need of kelp

Seaweed could feed the world, replace plastic and slash carbon emissions. **Chris Simms** trawls the evidence

Book

The Seaweed Revolution

Vincent Doumeizel
(translated by Charlotte Coombe)
Hero Press

NEXT time you have maki sushi, consider the nori seaweed it is wrapped in – it might well help save the planet.

As Vincent Doumeizel reveals in his book *The Seaweed Revolution*, the potential of seaweed, or marine algae, to transform our world is huge. If we could grow it sustainably, he writes, "seaweed could feed people, replace plastic, decarbonize the economy, cool the atmosphere, clean up the oceans".

It is quite a promise, but can it be fulfilled? Doumeizel is well-placed to find out. He is senior adviser on oceans to the UN Global Compact, the largest bid to get businesses to buy into sustainable, responsible policies and report on their progress.

His premise is that we are filling the atmosphere with climate-warming gases, overcultivating the land and depleting soils, leaving millions of people hungry or malnourished. Yet oceans, covering 71 per cent of Earth, are largely untapped. Of 48 million square kilometres of cultivatable ocean, we use just 2000 for food, contributing only 2 per cent of our calorie intake. Most of us could eat more seaweed and would probably be healthier for it, says Doumeizel. In Japanese cuisine, it already accounts for 10 per cent of daily calories.

Doumeizel details seaweed research, revealing, for example, that nori contains phytosterols, which prevent us from absorbing cholesterol and cut the risk of some cancers. Certain seaweeds also contain a wealth of fibre, vitamins and micronutrients, including omega-3s. Just think of the poor sailors who died of scurvy not knowing that 400 grams of the seaweed below them would have met their daily vitamin C needs.

The book is also persuasive on seaweed's role in absorbing carbon dioxide, saying it could mop up the equivalent of around 10 billion tonnes of CO_2 per year. That is about a fifth of all annual emissions. Giant kelp, in particular, can grow more than 50 centimetres a day, says Doumeizel, and absorbs a huge amount of CO_2.

He also points to work showing that adding red algae to the diets of ruminants like cows would alter their gut microbiomes, improve their digestion and could cut their methane emissions by 80 per cent. This alone would have an effect on greenhouse gases akin to banning cars immediately, he says.

Beyond this, there are the emerging uses of kelp to make environmentally friendly clothes, high-density bricks or biodegradable bioplastic, which could replace PET plastic. To do all that, we would need to produce several hundred million tonnes of kelp every year.

As for downsides, Doumeizel says that large-scale farming of one species can unbalance ecosystems, stressing that aquaculture can't be seen as a local endeavour because the sea carries fertilisers elsewhere, which could cause unpredictable growth surges. It will also transport seaweeds to places where they could spread invasively, so we need robust checks and quarantining.

This doesn't deter him: in his view, seaweed represents hope, with seaweed "fields" supplying food for billions, absorbing carbon and providing materials. He sees a multi-species aquaculture, farmed by underwater drones. Organic fish waste would be recycled by mussels and scallops, seaweed would mop up inorganic waste, and sea urchins and starfish would absorb leftovers.

We aren't there yet, though. So far, we have domesticated just 10 to 20 of the 12,000 seaweed species. As Doumeizel says: "What can we do with seaweed? Practically everything! What do we currently know how to do with seaweed? Practically nothing!"

Even so, the market has exploded from very little in 1950 to a global $14 billion now. Since reading this excellent book, my intake of seaweed has soared – even if I am not wearing kelp clothes yet. ▮

A marine forest, off the coast of northern California, is dominated by fast-growing giant kelp

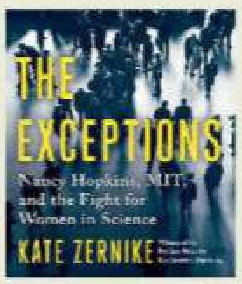
ETHAN DANIELS/SHUTTERSTOCK

Don't miss

NETFLIX

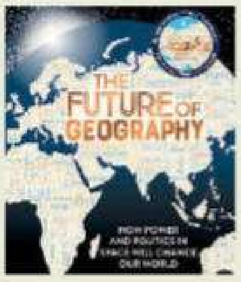
Watch

Sweet Tooth returns for a second season as Gus (above), a human-animal hybrid, is on the run from a group called the Last Men. Based on the Jeff Lemire comic, this fantasy dystopia streams on Netflix from 27 April (UK/US).



Read

The Exceptions tells the story of 16 scientists (all women) who forced their employer, MIT, to publicly admit that it had discriminated against its female faculty staff. By Kate Zernike, who broke the story for *The Boston Globe* in 1999. On sale now (US); 27 April (UK).



Read

The Future of Geography lies in space. If you are fascinated by the geopolitics and power struggles that might shape the final frontier, then try Tim Marshall's latest book. On sale from 27 April (UK).

The TV column

The power of two Reimagining a cult psychological thriller like *Dead Ringers* is a seriously tough ask. Amazingly, a six-parter starring Rachel Weisz as twin gynaecologists is a standalone triumph, says **Bethan Ackerley**

Bethan Ackerley is a subeditor at *New Scientist*. She loves sci-fi, sitcoms and anything spooky. She is still upset about the ending of *Game of Thrones*. Follow her on Twitter @inkerley

NIKO TAVERNISE/PRIME VIDEO

Fizzing with ideas: Rachel Weisz (right) and Britne Oldford in *Dead Ringers*

TV

Dead Ringers

Amazon Prime Video from 21 April

WE OFTEN make the mistake of seeing twins as incomplete halves of a single person, particularly if they are identical. Worse, they arouse notions of good and evil or nature and nurture, inviting comparison at every turn.

For some, it may be difficult to resist comparing a new TV version of *Dead Ringers*, airing on Amazon Prime Video, with the 1988 film.

The original is a maelstrom of psychosexual torment from director David Cronenberg, the uncontested king of the venereal and the visceral. Identical twin gynaecologists Beverly and Elliot Mantle (played with lurid aplomb by Jeremy Irons) swap personas and share sexual partners without those partners' knowledge. When one relationship unsettles their delicate balance, it leads to a violent identity crisis.

Fans of the film (I am one) might worry the TV show, steered by writer Alice Birch, will merely bang the same Freudian drum. Don't. This reimagining of Beverly and Elliot as sisters (played by Rachel Weisz) is its own animal. But it is every bit as red in tooth and claw as Cronenberg's film.

While the twins remain gynaecologists who swap their mismatched personalities – Elliot is childish and confident, Beverly is stony and stifled – their goals are very different. Rather than the avaricious misogyny that propels the brothers, the sisters are out to improve the reproductive health of everyone in their care.

> “This reimagining is its own animal. But it is every bit as red in tooth and claw as Cronenberg's film”

The show's gory scenes of birth and surgery are rooted in the real risks of childbirth. Two poignant scenes highlight the disparity in care received by Black women in particular. In one, a mother's post-Caesarean agony is fatally ignored by her doctor. In another, Beverly sees a vision of Anarcha Westcott, one of many enslaved women who, in the 19th-century US, were experimented on without anaesthetic by James Marion Sims, the “father of gynaecology”. As a viewer, you share the twins' desire to radicalise obstetrics.

That isn't to say the Mantles have been canonised. Elliot gets off on asking her patients' partners to expose themselves to her, and neither sister has qualms about Elliot seducing women on Beverly's behalf.

Despite some reservations, the sisters chase funding from the billionaire Parker family. Episode 2 sees the pair at a retreat for health magnates, full of smirking biohackers and simpering wellness gurus who are united only by their wealth and strange predilections. It is as darkly funny as anything in *Succession*.

If that wasn't murky enough, Elliot is pushing the ethical boundaries of reproductive tech. Again, Birch draws on the real world: we are at a point where our abilities to grow embryos for more than 14 days in the lab have outstripped legal restrictions.

Elliot pays no heed to such trivia as international law, illicitly culturing embryos for far longer, as well as experimenting on a woman in a desperate state who couldn't meaningfully consent. The show is never better than when it wrestles with the ways in which extraordinary advances in healthcare could lead to obscene inequality in the hands of the rich.

All of this should signal that the new *Dead Ringers* is fizzing with ideas, sometimes so much so that the six-parter had me breathless. I rarely found myself thinking about Cronenberg or Irons. This twisted romp through the frontiers of medical ethics stands completely alone, no comparisons required. ▮

Bethan also recommends...

TV

Orphan Black

All 4 (UK); on demand (US)

Con artist Sarah Manning witnesses the death of a woman who looks just like her. After assuming her identity, Sarah learns she has more doppelgangers.

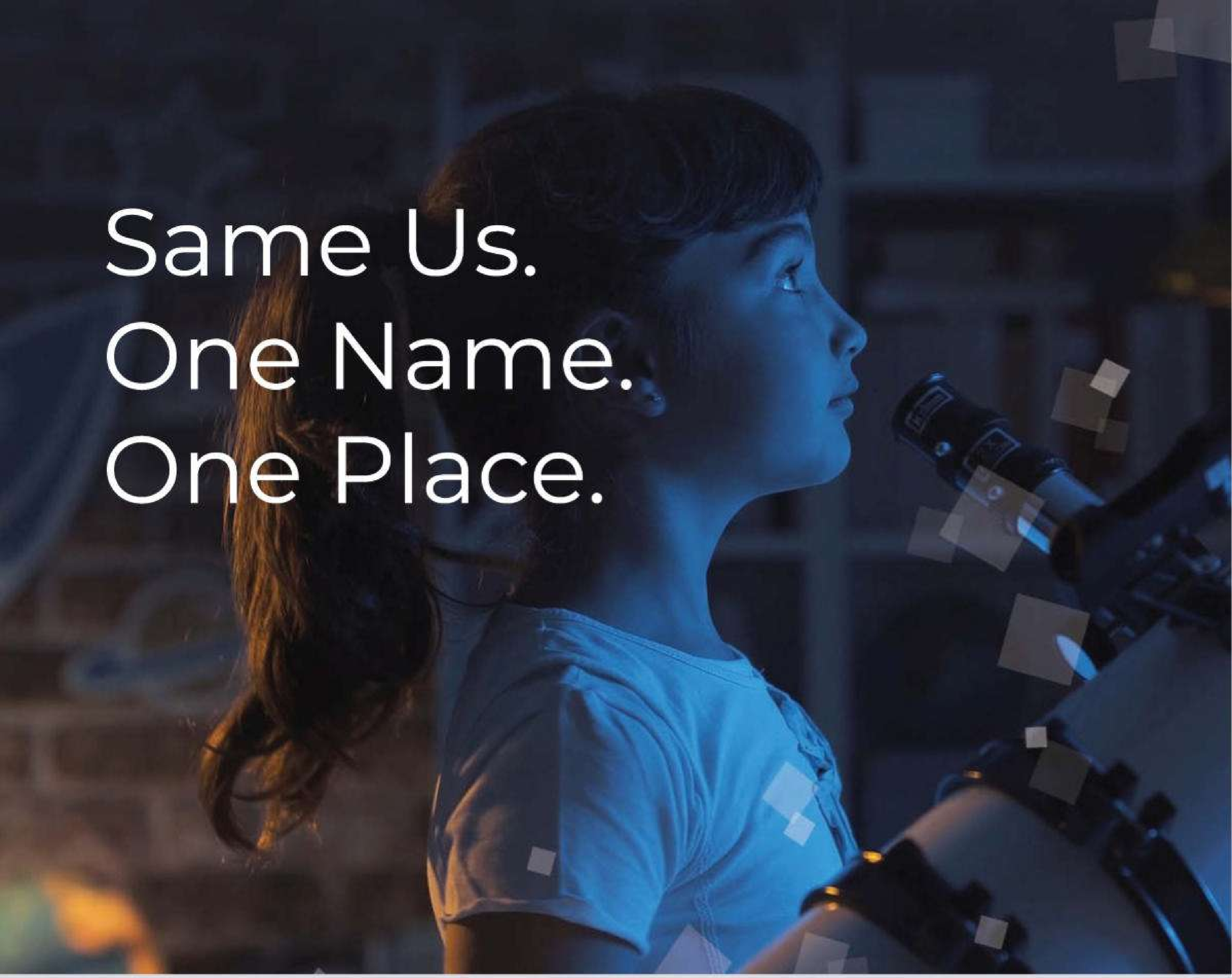
Film

Three Identical Strangers

Tim Wardle

Netflix

This documentary follows identical triplets adopted by different families. What happened when they were reunited is as fascinating as the circumstances of their separation are disturbing.


Same Us.
One Name.
One Place.

If you're considering your next career move, we can help you.

As specialists with over 30 years of experience in scientific and clinical recruitment, our recruiters have expert knowledge across the life science industries. We can help you find the role you've always dreamed of with some of the world's most innovative and successful organisations.

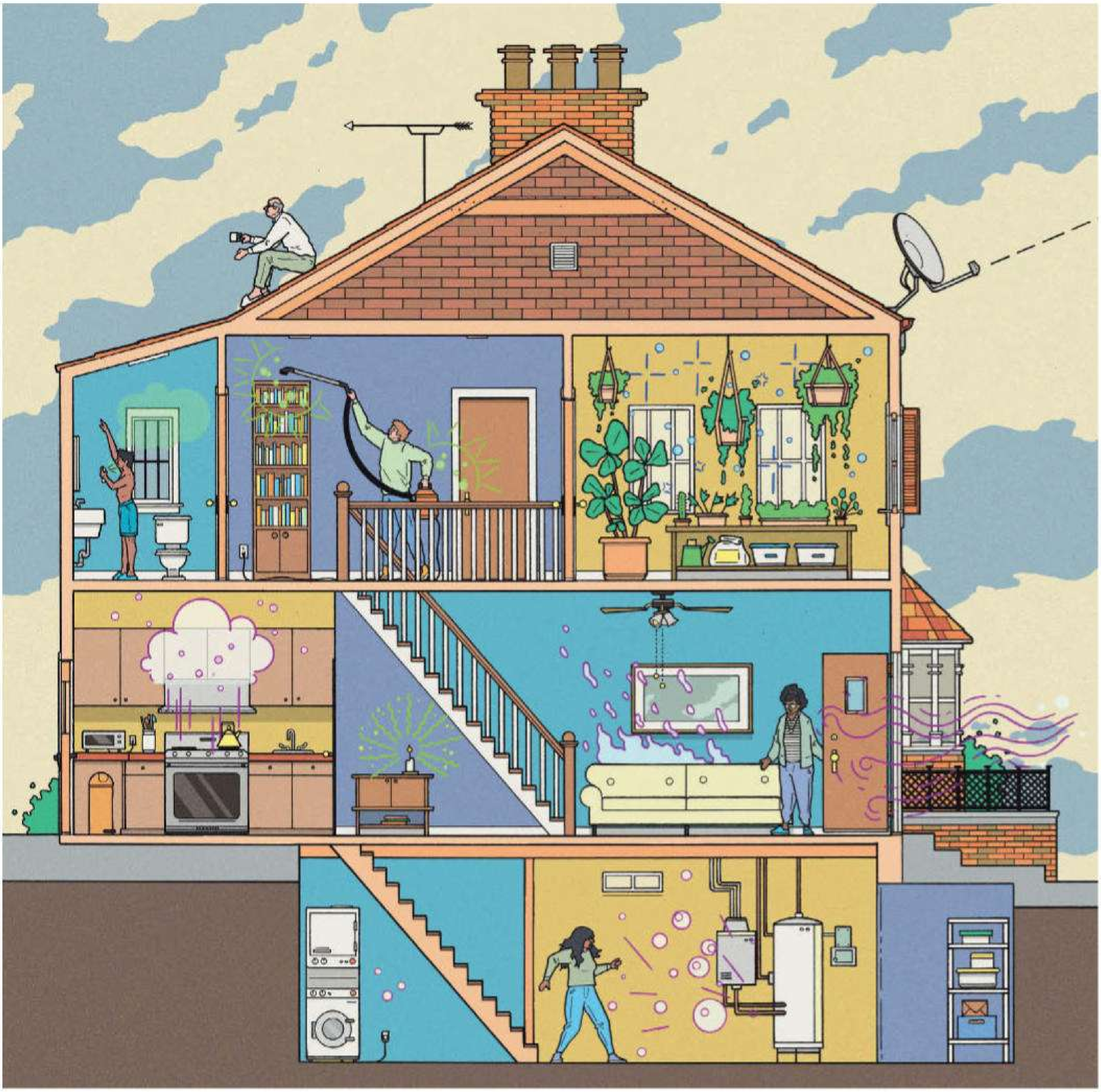
Find the job you've always dreamed of.

Search: ckgroup.co.uk **Call:** 01246 457700

CK Group
part of TALENTMARK

Better out than in?

Indoor air can be as dirty as a city street at rush hour. But making a few simple changes at home can help reduce the risks to health, says **Graham Lawton**



KYLE ELLINGSON

As I weave through the London traffic on my bike, I always worry about the filthy air I am breathing. It is a relief to get back inside, where the air is sweeter and, you might think, better for me. But that turns out to be a false sense of security.

"People don't imagine that there is pollution indoors; it is perceived as a protective place," says Corinne Mandin at France's Scientific and Technical Building Centre. "But there are more pollutants in buildings than in outdoor air."

Thanks in no small part to covid-19, which focused minds on air quality and ventilation of enclosed spaces, the long-neglected issue of indoor pollution is finally being taken seriously. Deadly seriously, in fact, as it dawns on scientists that the pollutants we encounter in our homes, workplaces and schools are probably a major cause of illness and death. Certainly in places where solid fuel or kerosene (paraffin) are used for cooking indoors, air quality-related deaths run into the millions, hence the suspicion of harm elsewhere.

Last year, the US National Academy of Sciences (NAS) published a weighty tome on the topic, which spelled out the huge gaps in our knowledge and said that filling them was a national priority. Other countries are doing the same, says Mandin. "Indoor air pollution is having a moment."

As this research gathers pace, and the true scale of the problem emerges, it is tempting to conclude that there is nowhere safe left to breathe. But the good news is that we can all cut exposure to indoor pollution by making a few simple changes.

As with all things to do with toxicity, the risks depend on exposure and dose. Exposure to toxins indoors is a problem partly because most of us spend the vast majority of our time inside. An average person in the US spends 69 per cent of their time at home and 18 per cent in other indoor locations. The doses we get indoors are often higher too: not least because, as covid-19 taught us, indoor nasties are less likely to dissipate, which makes it more likely that we will breathe them in.

The idea that the air indoors can be as bad or worse than outdoors first came to light in the early 1980s, when the occupants of new buildings started complaining of a range of persistent health problems such as headaches, coughs and sore throats. In 1986, the World Health Organization (WHO) coined the term "sick building syndrome" and research into its causes got under way.

The dirty half-dozen

The answer turned out to be polluted indoor air, often due to poor ventilation, furnishings releasing toxic chemicals and a lot of smoking. Six pollutants were fingered as the main culprits. Five of them were: tobacco smoke; carbon monoxide from faulty or poorly ventilated gas appliances; radon gas, from the natural decay of uranium, thorium and radium deep underground; and a pair of common industrial chemicals, trichloroethylene and benzene. These two substances come under the banner of volatile organic compounds (VOCs), so-called because they evaporate readily at room temperature and so leach out of everything from paint to furniture to flooring and electricals. The sixth offender comprised particles with diameters of less than 2.5 micrometres (known as PM2.5), tiny airborne agglomerations of organic chemicals, soot, metals, soil and dust.

Some of these pollutants, notably tobacco smoke, have become less of a problem since the 1980s, at least in public spaces in some countries. But better sampling and analytical methods mean we now know more about what is in the air we breathe, and the list of nasties has just kept growing. Synthetic dyes known as azo dyes – which are used in everything from clothing to mattresses and some of which have been shown to be toxic, carcinogenic and bioaccumulative – are one notable addition, along with many more VOCs and ever finer particles. The smallest of these, called ultrafine particles, measure 0.1 micrometres in diameter and are small enough to cross from the lungs into the bloodstream and settle in organs, triggering inflammation. In the heart and brain, they increase the risk of cardiovascular and neurological conditions. Even dust, which is mostly biological gubbins like dead skin cells, hair, fibres, pollen and mites, can trigger an immune reaction when inhaled and can act as a carrier of VOCs and other chemicals.

It is enough to make you want to crack open a window. But that needs some consideration. Outdoor air can bring in a constant payload of particulates, nitrous oxides and VOCs from traffic exhaust, as well as ozone, which is formed when nitrous oxides react with VOCs in the presence of sunlight. Ozone is a key player in indoor air quality, as it attacks otherwise innocuous compounds such as fragrance molecules and turns them nasty. "We know that indoor ozone drives lots of chemistry, and that chemistry leads to the formation of pollutants indoors, some of which are harmful to health, like formaldehyde," says Nicola Carslaw at the University of York, UK.

›

SHOULD I BUY AN INDOOR AIR QUALITY MONITOR?

There is nothing like researching an article on indoor pollution to make you worry about whether your home is toxic. So, I bought an indoor air quality monitor and decided to find out.

Most of the time, the air quality in my house is within safe levels, but it can quickly enter the danger zone via relatively innocuous activities.

I put it in the bathroom while I got ready for work and my aerosol deodorant triggered the total volatile organic compound (TVOC) alarm and also pushed all three categories of particulate matter (PM10, PM2.5 and PM0.1) to unsafe levels.

I fried some prawns without the extractor fan on. The PM quickly exceeded the machine's maximum reading, though dropped back to safe levels when I switched the extractor fan on. But then I turned the fan off, and they shot back up and stayed high for about 15 minutes even with a window open.

I also burned some incense, which sent it back into PM overdrive. I triggered the TVOC alarm by waving a Sharpie around and also by taking the monitor on a drive with the car windows closed. But I also got what I think must be false positives. I opened a beer next to it and the formaldehyde alarm went off.

Monitors need to be treated with caution, says Corinne Mandin at France's Scientific and Technical Building Centre. "They are useful, but they are not all tested and what is on the market is not always reliable. There is no standard today to assess the reliability of the sensors. We tested some in our lab, and some do not measure anything."

In response to a growing awareness of the threat of indoor pollution, the WHO set guidelines for exposure to five of the most common VOCs found in buildings, along with other common pollutants including carbon monoxide and radon. But the full burden of indoor pollution remains up in the air. "There's literally thousands of chemicals that might exist in the indoor environment, and for many of those chemicals, we have very little information regarding their toxicity," says David Dorman at North Carolina State University, lead author of the NAS report.

> **"As the list of indoor air pollutants keeps growing, so do the known unknowns"**

For those we do know about, there is good reason to sound the alarm. One VOC of particular concern is the industrial solvent trichloroethylene (TCE), found in glues, varnishes and cleaning fluids. TCE is a known carcinogen that has been linked to brain, liver and kidney damage with high or long-term exposures. Most of the studies so far have been done in industrial workers exposed to high concentrations due to their job. Less is known about the effects of low or occasional exposures, but the WHO guidelines advise caution, stating that, since there is sufficient evidence that TCE is a genotoxic carcinogen (a chemical that may cause alterations at the genetic level), "all exposures indoors are considered relevant and no threshold can be determined."

CATHERINE FALLS COMMERCIAL/GETTY IMAGES

Cooking is a big source of indoor chemicals, with frying producing more than boiling or steaming

It is a similar story for acrolein, a molecule produced by gas stoves, wood burners, deep fat fryers and by regular and electronic cigarettes. Studies suggest that sustained exposures cause respiratory and cardiovascular disease. Emissions from heated oil when cooking in unventilated kitchens has been linked to an increased risk of lung cancer. And an analysis that combined the results of many studies found that exposure to benzene indoors, from cigarette smoke or the infiltration of vehicle exhaust fumes, increases the risk of leukaemia, asthma and low birth weight: the higher the concentration, the higher the risk.

In general, though, we know very little for certain about the specific disease risks, but it is likely that indoor air pollution is taking its toll, says Mandin. A rise in asthma cases has been linked to outdoor pollution, so it makes sense that some cases can be attributed to indoor pollution. Mandin also suggests that it could be part of the explanation for unexplained migraines, and even some reproductive challenges. As yet, we can't be sure. The knowledge gap on the burden of disease caused by all this is so frustratingly wide that leading journal *Indoor Air* recently put out an urgent call for research papers to fill it.

So far, epidemiological research has proved difficult to do. "For outdoor air quality, you have one monitoring station and it represents the exposure of thousands of people. But for indoor air quality, each school, each classroom, each dwelling, each office is different," says Mandin. Something similar can be said for location: depending on where you live and how fresh the air is outside, the relative risks of indoor air vary considerably.

While we wait for a fuller picture to emerge, it seems sensible to reduce exposures as much as possible. Fortunately, there are a few easy ways to do this – at least at home, where we have the most control over our environment.

First up is cooking, which the NAS report calls "one of the most notable sources of

New Scientist audio
You can now listen to many articles – look for the headphones icon in our app **newscientist.com/app**

HAJARIMANITRA RAMBELOARIVONY/ALAMY

One of the many things you can do to reduce air pollution at home is to leave open fires unlit

indoor chemicals". The exact composition of the fumes depends on what you cook and how you cook it. Gas burners are the most polluting heat source, releasing carbon monoxide and dioxide and nitrogen oxides, which can accumulate without adequate ventilation.

As a rule, frying is more polluting than boiling or steaming, which produce mostly water vapour. Frying releases aldehydes and polycyclic aromatic hydrocarbons (PAHs) from the cooking oil and particulates from whatever you are frying. Meat can be an especially rich source of particulates, says Carslaw.

There are some signs that fumes from cooking meat could do more than just make us wheeze. Researchers at Nazarbayev University in Kazakhstan exposed volunteers to fumes from a chicken drumstick fried on a gas stove. Measurements of their brain activity with an electroencephalograph, or EEG, showed that, at peak exposure, it resembled that seen in people with a neurodegenerative condition. Activity did return to normal after 30 minutes, but the researchers warned that chronic exposure may cause long-term damage.

Frying or griddling less and boiling or steaming more is an easy way to reduce these kinds of exposures. Another easy option is to always use an extractor fan, if you have one. "I think a lot of us will never cook again without turning our fans on," says Vicki Grassian at the University of California, San Diego, speaking for the co-authors of the NAS report.

Outside the kitchen, it might be a good idea to leave wood burners and open fires unlit, and avoid scented candles, air fresheners and other superfluous smellies. "People think that air fresheners, incense and essential oils are good for indoor air quality, that they will clean the air and degrade pollutants, but no, they emit pollution," says Mandin.

Crack open a window

House plants have a reputation as air cleaners, but research suggests that most homes would need thousands of them to make a difference. Good ventilation, however, works well, reducing the concentration of pollutants generated indoors. It does invite ozone in, but unless you live on a busy road, on balance, fresh air has a positive effect, especially when the sun isn't shining and ozone production is low. Air-scrubbing technology such as HEPA (high-efficiency particulate air) filters and air conditioning units can help, but are expensive. A cheaper fix is to buy a device to measure air quality (see "Should I buy an indoor air quality monitor?", left), which can be had for less than £100, and hotfoot it from spaces where the pollution is bad.

And don't overdo the cleaning. Dusting and vacuuming resuspend dust, creating an inhalation hazard. Use a wet cloth rather than a dry duster or vacuum cleaner, Mandin suggests. Choose cream cleaners and roll on deodorants instead of sprays, too.

It is also a good idea to leave any new furniture and furnishings in a well-ventilated space for a few days before putting them in position. "New furniture will emit a lot of volatile organic compounds," says Mandin.

Nevertheless, some level of indoor air pollution is inevitable and we shouldn't jump to the conclusion that we are being poisoned in our own homes, says Dorman. "There are research needs and scientific gaps in our knowledge, but that doesn't necessarily mean that everybody is at some great risk," he says.

These gaps are being filled all the time. New methods that allow scientists to sample an environment and capture all the chemicals it contains are providing a clearer image of what is in the air. One recent study using this approach discovered a class of airborne toxic compounds called N-chloraldimines in a gymnasium, formed from a reaction between amino acids in sweat and a bleach used to clean the exercise equipment. A similar technique found that the antibacterial triclosan is ubiquitous in indoor air. "When we were not able to measure it, we thought it was only in toothpaste," says Mandin. Other recent discoveries include those azo dyes, plastic additives called ultraviolet stabilisers, the herbicide glyphosate in dust, and compounds from detergents that are released when clothes are dried on a radiator. As the list keeps growing, so do the known unknowns.

Another research challenge is to work out how different chemicals mingle and react with each other. "We're being exposed to multiple chemicals simultaneously in the indoor environment and we have chemical-chemical interactions that are not fully understood," says Dorman.

There may still be much to learn, but just like sick building syndrome triggered a flurry of discoveries, covid-19 has also put a burner under research into indoor air quality. "I think it's a new dawn," says Dorman. "We'll know more in 10 years than we do now." In the meantime, if you need a rule of thumb, think "ventilation, ventilation, ventilation". ■

Graham Lawton is a features writer at *New Scientist*

As tricky as ABC

CALLIE LIPKIN/GALLERY STOCK; NEW AFRICA/SHUTTERSTOCK

We know how young minds learn to read, so why are so many children failing to master this essential skill, asks **Colin Barras**

MORE than 5000 years after the invention of writing, you would think we would have completely nailed the best way to teach people to read – literacy is a key skill in most societies, after all. But you would be wrong. Not only have scientists long disagreed on the most effective methods, but their arguments have fuelled a decades-long, politicised "reading war" over how to teach children to read English.

Meanwhile, large numbers of children are struggling to achieve the standards they should for their age. Last year, just 33 per cent of 9 and 10-year-olds in the US were assessed as being proficient or advanced readers. "The US has done poorly in teaching kids to read for a long time," says Mark Seidenberg, a cognitive neuroscientist at the University of Wisconsin-Madison. And the problem isn't confined to English-speaking countries: there is also confusion about how to teach children to read other languages.

A key battleground is a teaching technique known as phonics. In the US, poor literacy is often blamed on having too little phonics in the classroom. But, confusingly, researchers last year argued that children in England are being failed by being taught too much phonics. Herein lies the root of the problem: it is one thing to understand how kids learn to read and, it turns out, quite another to figure out how best to teach them. The good news is that researchers, having begun to enter the classroom, are finally getting to grips with how they can translate their insights to improve teaching and, ultimately, bring an end to the reading wars.

For 400 years or more, there has been debate about the best way to teach reading. Today, most reading researchers say the learning process begins when the student – generally assumed to be a child – realises that the words they speak can be represented by text. A child learning an alphabetic script like English must also recognise that spoken words can be broken down into small elements called phonemes – the /k/ sound in "cat", for instance – and that the alphabetic letters, or graphemes, represent these phonemes. With time, the child learns to associate each grapheme with one or more phonemes, and to blend strings of phonemes together to make words. They can then turn a written word, such as cat, first into a set of discrete phonemes – /k/a/t/ – and then into the spoken word "cat". Researchers call this decoding. Formal instruction in decoding , otherwise known as phonics, allows children to read many written words. Ultimately, those words become familiar enough that the child recognises them instantly and knows how to pronounce them without decoding.

"Phonics has been a part of reading education in England since the 19th century," says Dominic Wyse, who studies early education at University College London (UCL). But in 2006, after the publication of a government-commissioned independent review of teaching methods, phonics instruction gained a more dominant role. This is what is undermining reading education in England, Wyse and Alice Bradbury, also at UCL, concluded last year after surveying more than 2000 teachers.

> **"Last year, just 33 per cent of 9 and 10-year-olds in the US were assessed as proficient readers"**

The trouble is that there is much more to reading than just decoding. Take a simple written word like bow, which has several meanings and two distinct pronunciations. Decoding alone won't help someone select the right combination of these. They must also use contextual cues from the text, such as the context contained in an entire sentence: "bow if you meet the king" versus "I can tie a bow", for example. In other words, children need to understand what they read.

We have known for decades that reading instruction is less effective if children are taught to decode lists of words shorn of context. Better results are seen when they learn using books. In addition, it helps for teachers to emphasise that decoding is a tool to aid reading comprehension. Some reading researchers say teachers in England do this. But Wyse and Bradbury found that only about a quarter of the teachers in their study agreed that they did. Wyse thinks there are several reasons for the excessive focus on phonics, not least that young children are required to take a national test that assesses their ability to decode. "Teachers will teach to the test because there are implications if the children don't pass," he says.

The situation is different in the US. For years, teachers in many states have placed books at the heart of the reading curriculum and encouraged children to derive meaning from them. In recent years, however, prominent commentators have argued in news articles and podcasts that this approach is largely to blame for the reading crisis in the US. How can that be, given what the science says?

The problem is one of emphasis. The reading approach long favoured in many US schools is known as the "three-cueing system" because it instructs children to use three different

›

strategies while reading. Two of those "cues" are semantics (meaning) and syntax (sentence structure): in essence, using contextual cues to check whether the words make sense. That fits with the science. However, children may then be encouraged to use this information to predict – or, more bluntly, to guess – what word comes next in a sentence. (The boy is flying his… what? Perhaps his kite?) Then comes the third cue: they look at the letters in that word and check whether or not they match their prediction.

This may sound curiously back-to-front. In fact, very few reading researchers recommend the three-cueing system because it puts decoding at the end of the reading process rather than at the beginning. However, some are equally concerned that the backlash against it has seen commentators suggest children shouldn't be taught to use cues at all because they can get in the way of their reading development. This could lead to reading curricula in the US that contain phonics and little else, says Donna Scanlon at the University at Albany, New York. She points out that many schools experimented with such an approach in the early 2000s, during a federal education programme called Reading First. A government assessment of the programme was published in 2008. "Kids got better at phonics, but they didn't get better at reading comprehension," says Scanlon. Other researchers argue that methodological problems with the assessment make it far from clear that Reading First turned children into great decoders but poor readers. Nevertheless, Scanlon's concerns do mirror those of Wyse and Bradbury.

Balancing act

What is needed, say these researchers, is a balanced approach to reading instruction that encourages children to complement decoding with contextual cues while remembering that the goal of reading is to understand texts. Over the past 25 years, Scanlon and her colleagues have been working on exactly such a method, and their research suggests that the strategy is effective. However, it is specifically designed to help children identified as having difficulties with reading, in small groups or even one-to-one. We still don't really know the best way to teach such skills to a classroom of children, for the simple reason that understanding the teaching of reading, as opposed to understanding how children learn to read, hasn't always been a research priority.

"It's one thing to say: we know how the brain learns how to read," says Emily Solari at the University of Virginia. "It's another thing to say: we know how to take that science and translate it into effective practices that teachers can actually implement." What researchers like Solari are discovering is that getting an evidence-based answer to that question is far from easy. "It's really hard to do that kind of research," says Seidenberg. "There are so many factors floating around."

For instance, it is widely accepted that hunger influences children's ability to learn – which means that, in theory, a child may respond to the same lesson differently on a full or empty stomach. "Hunger is a huge component to engagement," says Jessica Jang, who teaches first grade (6 and 7-year-olds) in a school in California. "When a student is hungry, this can result in misbehaviour, such as withdrawing from the lesson or causing disruptions."

Teachers also need to recognise that children from different backgrounds may have different needs. Bryant Jensen at Brigham Young University, Utah, points to some research showing that Navajo Native American children tend to feel embarrassed if they are singled out for praise during reading lessons, which can undermine their willingness to participate in classroom activities.

What's more, Patrick Proctor at Boston College in Massachusetts and Chris Chang-Bacon at the University of Virginia have noted that the standards used to assess reading in the US are usually based on the performance of monolingual English speakers. This means that a teacher may, for example, have a narrow sense of the correct pronunciation of a word, and assume a child who pronounces it differently is struggling with decoding.

Proctor says researchers must spend time in the classroom. By observing teachers and children and talking to them, they can go beyond asking whether a curriculum is effective and begin to understand why. Since 2014, he and his colleagues have been working in US schools to develop a literacy curriculum for multilingual students that plays to their strengths. For instance, it uses video to communicate information through

Raising a reader

Here are four expert tips on what parents and caregivers can do to help prepare young children to learn to read

Talk a lot

"Speak to your kids," says Patrick Proctor at Boston College, Massachusetts. This builds up vocabulary and conceptual knowledge. It's far easier for a child to understand a written word like tiger if they know what a tiger is.

Shift your perspective

"Position yourself as a learner," says Bryant Jensen at Brigham Young University, Utah. By appreciating how books can thrill a curious young mind, you can help a child develop a reading habit.

Encourage writing

"Let a child try writing their name," says David Share at the University of Haifa in Israel. It's a great way to help them recognise that letters represent spoken language. "Don't worry about correct spellings. That comes later."

Make it fun

"When children read more, they learn to read better," says Dominic Wyse at University College London. A young child who enjoys being read to is developing a love of books that will help motivate them to learn to read.

JAHI CHIKWENDIU/THE WASHINGTON POST VIA GETTY IMAGES

When learning to read, children from different backgrounds may have different needs

images, action and sound to help them expand their vocabulary both in English and in the other language or languages they use – a vital skill for readers.

At a broader level, there is more awareness today that children face different demands depending on the language they are learning to read. For example, a strong focus on phonics makes sense when teaching children to read English, given the irregular spelling of many English words. But other languages, including German and Spanish, are far easier to decode so children don't need to devote months or years to phonics lessons, says David Share at the University of Haifa in Israel. Then there are non-alphabetic languages where individual symbols may represent whole words rather than phonemes, which makes phonics instruction far less important.

> **"We still don't really know the best way to teach these skills to a classroom of children"**

Lost in translation

Share believes that the reading crises in some parts of the world may reflect the progress made in understanding reading in English. The problem is that English-specific findings might influence reading education policy in countries using writing systems for which they aren't applicable. Sonali Nag at the University of Oxford has come across many examples of this. One is the assumption that children will learn all of the characters of a writing system in their first school year – which may be true of an alphabetic writing system with a few dozen symbols, but not for non-alphabetic writing systems with hundreds or even thousands of symbols. "It's blindingly obvious, but it's not in the theoretical models," she says.

Reading science has little to say about non-alphabetic scripts, such as Kannada

ARUNABH BHATTACHARJEE/ALAMY

For Nag, the solution is to ramp up research into understudied writing systems so that educational policies can be based on relevant reading science. Her work focuses on the "alphasyllabic" writing systems of South and South-East Asia. Unlike the alphabets common to Europe and North America, here the units used to construct words – called akshara – are usually based on a single consonant that is modified by a smaller vowel symbol. This means akshara often represent syllables rather than phonemes. Nag has begun examining children's literature across Asia – such as that written in the Kannada script used in south India – to better understand the range of words encountered by young readers in this region.

Taking this international perspective is a win-win. In a recent paper, Share explained how studies in non-English reading can also advance English reading research. For instance, researchers studying reading acquisition in easy-to-decode languages, such as German, tend to use different measures – particularly fluency – to assess how well children are learning. Partly as a result of this, fluency has become widely recognised as an important measure of reading performance in English. It has even influenced the way scientists think about dyslexia, which they now see as including problems with fluency and not just problems with decoding words.

Despite talk of reading crises in the US and elsewhere, in recent decades, reading research has greatly increased our understanding of how children learn this key skill. That is good news for parents and caregivers who want to help their children reach their full potential (see "Raising a reader", page 44). Clearly, though, there is still plenty to do – even if it appears that reading researchers now seem to be slowly moving in the right direction. "Translation of evidence into practice takes a really long time," says Solari. "If this were easy, we would already have figured it out." ▮

Colin Barras is a features editor at *New Scientist*

“Are AIs doing something like human reasoning?”

As ChatGTP disrupts our lives from every angle, it seems like a new kind of machine intelligence may be upon us. **Melanie Mitchell** talks to Daniel Cossins about how to understand this moment

ARTIFICIAL intelligence has been all over the news in the past few years. Even so, in recent months the drumbeat has reached a crescendo, largely because an AI-powered chatbot called ChatGPT has taken the world by storm with its ability to generate fluent text and confidently answer all manner of questions. All of which has people wondering whether AIs have reached a turning point.

The current system behind ChatGPT is a large language model called GPT-3.5, which consists of an artificial neural network, a series of interlinked processing units that allow for programs that can learn. Nothing unusual there. What surprised many, however, is the extent of the abilities of the latest version, GPT-4. In March, Microsoft researchers, who were given access to the system by OpenAI, which makes it, argued that by showing prowess on tasks beyond those it was trained on, as well as producing convincing language, GPT-4 displays “sparks” of artificial general intelligence. That is a long-held goal for AI research, often thought of as the ability to do anything that humans can do. Many experts pushed back, arguing that it is a long way from human-like intelligence.

So just how intelligent are these AIs, and what does their rise mean for us? Few are better placed to answer that than Melanie Mitchell, a professor at the Santa Fe Institute in New Mexico and author of the book *Artificial Intelligence: A guide for thinking humans*. Mitchell spoke to *New Scientist* about the wave of attention AI is getting, the challenges in evaluating how smart GPT-4 really is, and why AI is constantly forcing us to rethink intelligence.

Daniel Cossins: There is a groundswell of interest in AI at the moment. Why is it happening now?
Melanie Mitchell: The first thing is that these systems are now available to the public. Anyone can easily play with ChatGPT, so people are discovering these systems and what they can do. More broadly, we are seeing an era of astounding progress in linguistic abilities. Over the past five years or so, we’ve seen the emergence of these large language models, trained on enormous amounts of human-generated language, and they’re able to generate fluent, human-sounding text.

Their fluency gives the appearance of human-like intelligence. That has caught people’s imagination; there’s this feeling that the AIs we’ve seen in movies and read about in science fiction are finally here. I think people are feeling both wonder and partly fear at what these AIs might do.

You mention “human-like intelligence”. Just how intelligent are today’s generative AIs, like those that generate text, and how do we assess that?
This is the subject of enormous debate. The number one reason for that is that all these terms we’re concerned with – intelligence, understanding, consciousness – aren’t well defined. The second reason is that these AI systems work very differently to human minds. Recently we saw that GPT-4 managed to pass the bar exam, a standardised test that people must pass to be able to practise law in the US. If a human did well on this test, which involves multiple choice questions and writing a law essay, we would assume they had a lot of general intelligence. But who is to say such tests are an appropriate way to assess AI intelligence?

What do these large language models actually do, and what might that amount to in terms of intelligence?
Let’s start with the concept of a simple language model. I take a sequence of words like “the green frog” and then I look for those words in a huge amount of text and see what words typically follow that phrase. So it might be “jumped” or “swam” or, less likely, “cauliflower”. What’s the probability of each of these words coming next? I store those probabilities for lots and lots of possible sequences of words. Now I can start out with a text prompt and I can look up what is the most probable next word. This is how a simple language model works.

These days we give huge neural networks this task of working out the word probabilities and we train them on truly enormous numbers of examples from written text. These huge neural networks are called “large ›

NABIL NEZZAR

language models" (or LLMs) and they learn very complex statistical associations among phrases. The problem is that due to the complexity of the neural network and its operations, it's hard to look under the hood and say exactly what it has learned [in order] to predict those next words.

> "We can learn a lot from AI about how human intelligence works"

So, you could say these AIs are just predicting the next word, which doesn't sound impressive. But you might argue that this ability amounts to something like human intelligence.
Yeah, it's murky. There are basically three ways in which we can assess a language model. One is that we can interact with it, like I would with a human. You talk to it, give it questions, puzzles, see how it reacts – and form your impressions. That's like the Turing test, which basically asks: does this machine seem human? The problem is, we humans do tend to easily attribute intelligence to things that aren't intelligent.

Another way is to try something like giving an AI sets of two sentences, where, in one set, the first sentence logically implies the second is true, and in the other set there isn't that logical connection. These LLM systems have done extremely well on knowing which sentences are logically connected. But it often turns out that they do well not because they understood the sentences the way a human would, but because they were using subtle statistical associations.

Finally, you can look at the neural network itself and try to pull out an understanding of the mechanisms by which the machine is solving problems. People are working on that. But it's incredibly difficult because the system is so complex. So, ultimately, we don't yet have a cut-and-dried, problem-free test for intelligence in these language models.

Do you think our attempts to get to grips with the capabilities of AIs will force us to sharpen our definitions of intelligence and understanding?
That's been the case throughout the whole history of AI. In the 1970s and 80s, a lot of people were saying, well, playing chess at a grandmaster level is going to require general human-level intelligence. Then we got Deep Blue, the supercomputer that beat the grandmaster player Garry Kasparov, and we say it won by brute force, searching out the best possible moves. And here we are again. You could say we keep moving the goalposts. But I would say, in a more positive framing, that AI continues to challenge our conception of what intelligence is, or what we mean by understanding.

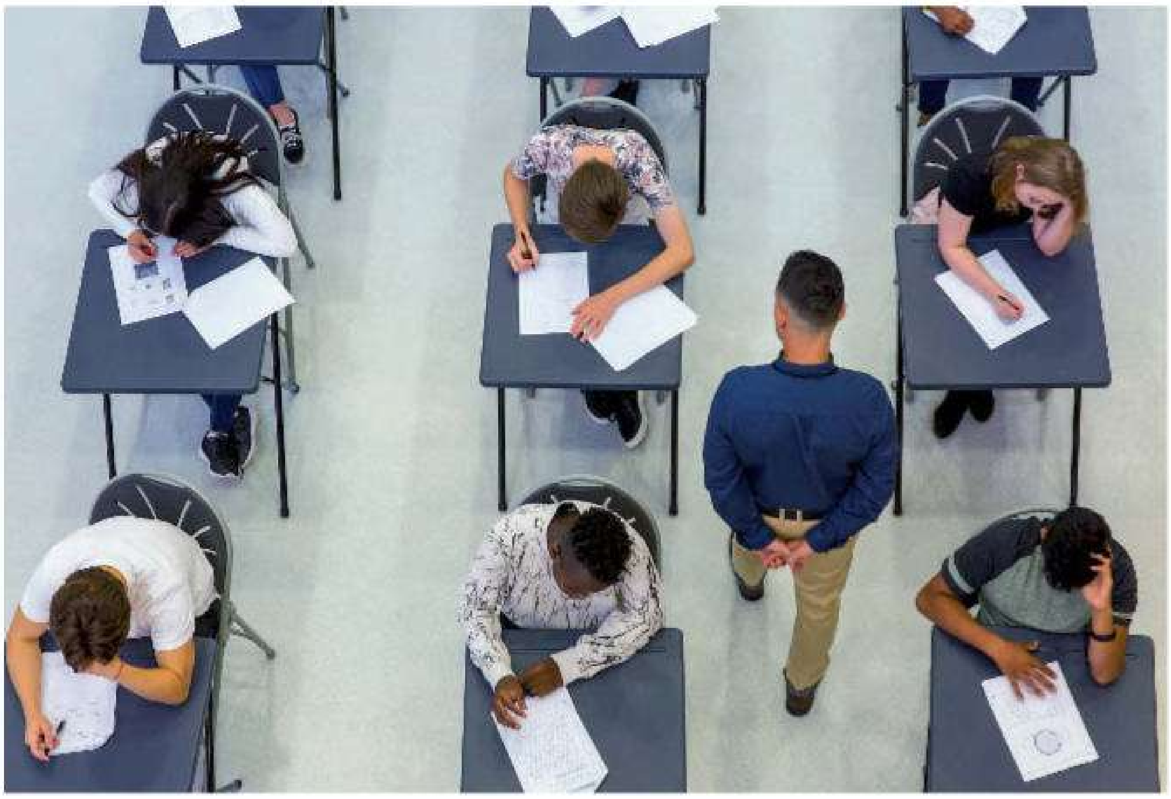
The thing is, we know that there are several different manifestations of intelligence. There's human intelligence, which is very different from, say, the intelligence of an octopus, and again from the powers of a generative AI. Some of us have been using the phrase "diverse intelligences", plural, to emphasise that intelligence isn't one thing. How do we characterise these different intelligences? Are there any common features? Are they wholly different? These are the questions we want to grapple with.

Is there anything that has surprised you in what large language models can do?
We have recently seen what people are calling "emergent behaviours" – abilities that go beyond language processing and can seem like human reasoning. You can give an LLM math problems or instructions for writing computer code. You can give them stories and ask them to reason about the characters. And they can do these things. It's not at all clear how this happens. They give the impression that they're able to understand the world, in some sense, having just been trained on enormous amounts of human-generated text. The question is, are they doing something like human reasoning? Or are they just using sophisticated statistical associations, which doesn't seem to be the way that we reason.

What are the leading ideas for what is behind these emergent behaviours?
It's a bit too early to say, because every other month we get a new version of these models that can do new things. With GPT-3, we could at least look at the training data. But with GPT-4, we have no access to this. OpenAI says this is a commercial product, so it doesn't want to give an advantage to the competition. It also cites "safety implications". There's no transparency there, so it impossible to do the research.

JEFF CHRISTENSEN/REUTERS/ALAMY

Chess grandmaster Garry Kasparov takes on a supercomputer in 2003



CAIA IMAGE/GETTY IMAGES

The GPT-4 AI recently passed an exam for aspiring lawyers

Do you think we are already on a trajectory to AIs with something akin to general intelligence? Or do you think that will require a whole new approach?
We first have to ask: what is general intelligence? Again, we don't have an agreed definition, so saying what it takes to get there is difficult because I'm not totally sure what the target is. I've heard a lot of people in psychology questioning whether humans have general intelligence. Human intelligence is very specific to our evolutionary niche and it might not be as general as we like to think it is.

That said, I think simply scaling up these models is probably not going to take us to the kind of human-like understanding that we want. We don't want just linguistic understanding; we want visual understanding, the ability to understand and do the right thing in a given situation.

To get to that point, I think we will need some different kinds of architectures. For example, language models like GPT-4 have no long-term memory so they have no recollection of past conversations and they don't care, in some sense, about what they have said in the past. It has been pointed out that a lot of human intelligence is centred on our motivations; that human intelligence is a means to achieve the goals that evolution has set for us. If a system doesn't have any motivations, or any of its own goals, maybe it can't achieve the kind of intelligence that we have.

What do you make of the idea that AIs can or will become sentient or conscious?
As philosophers have pointed out for millennia, how do I even know that you're conscious? I know that I'm conscious because I can feel it somehow. But maybe you're just a zombie. I guess I prefer not to go there because I don't understand what is meant by it and I feel like the discussions never go anywhere.

How might these language models be used once they are embedded in our daily lives? And what will be the nature of our relationship with them?
There will be lots of prosaic applications, like having them write your emails or reports. I think they will make us more productive. Whether there's going to be something more dramatic, it's harder to predict. Maybe they will put lawyers out of business. Maybe doctors will use them to help diagnose diseases and make decisions about our healthcare. I don't know. But right now, they have a lot of limitations that mean you really have to have a human in the loop. We need to have the ability to distinguish truth from falsehood and that ability is missing from LLMs – that's a fundamental problem.

Last month, a large number of high-profile AI experts signed an open letter calling for a moratorium on AI research. Is it possible that we are moving too fast?
Yes, it is possible. Technology often moves faster than policy and regulation. With AI specifically, there are a lot of risks with deploying these systems in healthcare, legal contexts, journalism – all kinds of areas. But I didn't sign that letter because I thought that it conflated a whole bunch of things, some of which were real risks and some of which are fearmongering science fiction. It painted a doomsday narrative that I don't buy into.

I do think we should have regulation. These systems can be dangerous in prosaic, everyday ways: bias and misinformation, that kind of thing. But I don't know if pausing research on them is the right way to go. Rather, we should know what data they're trained on. We can't just let companies like OpenAI effectively say: trust us, we know what we're doing.

What messages would you like to impart to help people think about the risks and benefits of AI at the moment?
First, these systems are not yet reliable. Nor are they conscious. They're not deciding to do anything that might be harmful to us. The real potential for harm is in humans using them, and therefore we do need to regulate them.

Second, just because we don't understand precisely how they work yet doesn't mean they're magic. It's just that they're very complex. We will be able to understand them. We just need to do the science, and to do the science we need these systems not to be entirely in the hands of for-profit corporations.

These language models offer a great opportunity to deepen our understanding of cognition. We can learn a lot from them about ourselves, about how human intelligence works and how intelligence more generally might work in diverse ways. But at the same time, we must be aware of all the dangers, risks and issues that are involved with deploying them in the real world. ▮

For more on this, read our analysis of AI's new wave (p12) and a potent warning about future risks (p27)

Daniel Cossins is head of features at *New Scientist*

INCLUDED WITH
YOUR SUBSCRIBER BENEFITS

New
Scientist
Subscriber
Event

ONLINE AND
IN-PERSON EVENT

THE SEARCH FOR
DARK MATTER

7 June, 7 - 8.30pm BST, Conway Hall, London, and online

Join a leading astrophysicist and a panel of *New Scientist* journalists for a deep dive into dark matter. You'll discover why our current model of the universe needs this mysterious substance to stop galaxies tearing themselves apart. You'll also learn how physicists around the world are striving to detect dark matter directly, including at a laboratory 2 kilometres underground in Canada.

To register your place, visit

newscientist.com/darkmatter

You will need your eight-digit subscriber number which can be found on our customer service and event emails, and above your address on your print copy.

Scan me to register

The back pages

Puzzles
Try our crossword, quick quiz and logic puzzle p53

***Almost* the last word**
Why do people and animals hiss to show disapproval? p54

Tom Gauld for *New Scientist*
A cartoonist's take on the world p55

Feedback
Exploring readers' mastery of space and time p56

Twisteddoodles for *New Scientist*
Picturing the lighter side of life p56

The science of cooking

Dispelling microwave myths

What is really going on when we microwave our food? **Sam Wong** digs into the science – and makes a tasty cake in just a few minutes

Sam Wong is assistant news editor and self-appointed chief gourmand at *New Scientist*. Follow him @samwong1

What you need

4 tablespoons self-raising flour
4 tablespoons sugar
2 tablespoons cocoa powder
1 egg
3 tablespoons milk
3 tablespoons vegetable oil

I LIVED happily without a microwave for 10 years, but, since acquiring one when I moved house last year, I have come to appreciate what a useful gadget it is. I have also realised that much of what I thought I knew about microwaves wasn't quite right.

Microwave ovens work using electromagnetic waves, also called microwaves, with wavelengths of 12 centimetres or so – much longer than visible light, but shorter than most radio waves. Microwaves create an oscillating magnetic field that puts certain molecules in a spin: namely, molecules like water, which have positively and negatively charged portions. Anything containing such molecules is heated up by the waves. Other molecules absorb the energy less efficiently.

The rotating plate inside a microwave oven ensures that all surfaces of the food are equally exposed to the microwaves. But the waves lose energy as they pass through food, so anything more than 2 centimetres or so from the surface won't heat up much. This means it is a myth that microwaves heat food from the inside out.

Melting ice in a microwave, or defrosting frozen food, takes longer than you might think because water molecules in ice are locked into a crystal structure and aren't able to rotate.

Some people worry about standing near a microwave while it runs, but this is quite safe: the waves can't escape the metal walls. Also, the door has a metal grid behind it and the waves are too big to fit through the holes.

NATALIIA SUIETSKA/SHUTTERSTOCK

As a child, I was told never to put metal in a microwave, but this won't necessarily lead to disaster. When microwaves hit metal, most of the energy is reflected – so, if you try to warm up food in a foil container, the metal will shield the food and stop it heating up. However, microwaves can push electrons around in the metal, and when they collect on a jagged edge or the point of a fork, they may create a spark. So, it is still best not to put metal in a microwave, aside from some products such as microwave sandwich toasters, which are designed to be safe.

A typical microwave runs on about 1000 watts, meaning it uses about half as much energy as a conventional oven for each minute it is on. It heats food faster, too, so it doesn't need to be used for as long. Cooking a jacket potato in the microwave requires about 80 to 90 per cent less energy than doing so in an oven. You can also steam vegetables in a microwave, using about half as much energy as on an induction stove.

Perhaps the most joyful use for a microwave is to make a single serving of cake in a few minutes. In a large mug, mix the flour, sugar and cocoa powder, then mix in the egg with a fork. Add the milk and oil and mix again. Cook it in the microwave for 1.5 to 2 minutes and watch it rise out of the top of the mug like a soufflé – it will sink when you stop the microwave. ▮

These articles are posted each week at newscientist.com/maker

The science of cooking appears every four weeks. Share your cooking successes with us on Twitter and Instagram @newscientist, using the hashtag #NewScientistCooking

Next week

Stargazing at home

It all started when I tried to grow Golden Promise....
McLACHLAN

As our farmers know all too well: no pain, no grain.

They say nothing worth having comes easy. Unfortunately for our farmers that's true of the barley we use to brew our beers. We use a classic variety called Golden Promise, grown to our own unique specification. The biscuity, golden malt it produces is the perfect partner to our natural spring water, and is vital to Landlord's depth and delicate balance of flavour. It's also a type of barley that's notoriously hard to grow, and our exacting specification makes it even more difficult. Which makes it a costly ingredient and a real challenge even for experienced farmers. Luckily we can offer some liquid therapy.

All for that taste of Taylor's

TIMOTHY TAYLOR'S
1858
CHAMPIONSHIP BEERS
LANDLORD
THE CLASSIC PALE ALE ABV 4.3%

New Scientist Podcast

The New Scientist Weekly podcast

Our prizewinning show brings you a curated selection of the essential stories of the week.

Hosted by *New Scientist*'s Rowan Hooper and Penny Sarchet. Feed your curiosity, for free, every Thursday. Make your week better with New Scientist Weekly.

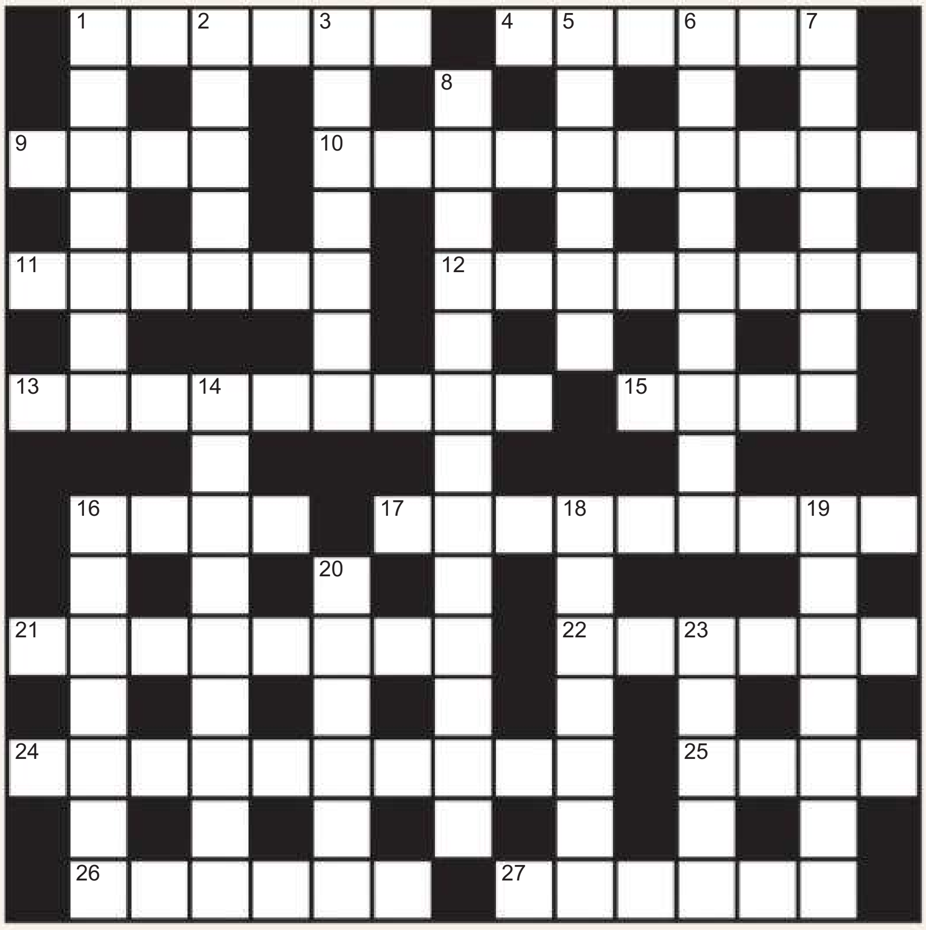
Penny Sarchet

Rowan Hooper

Follow us on Twitter **@newscientistpod**

Listen on Apple Podcasts
Listen on Spotify
Listen on Google Podcasts
Listen on Stitcher
YouTube

Quick crossword #131 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Isolated landmass (6)
4 A score (6)
9 Rafter or girder (4)
10 Rosebay ___, plant also known as bombweed or fireweed (10)
11 Multidirectional sound production (6)
12 Relating to the abdominal organs (8)
13 Mn (9)
15 Not false (4)
16 Wheel shaft (4)
17 Pain relief (9)
21 Material; solid (8)
22 Spotted cat of South America (6)
24 Expert in infectious diseases (10)
25 Flag, perhaps (4)
26 Type of board game piece (6)
27 Fatigue associated with travel between time zones (3,3)

DOWN

1 Principle defined in Newton's first law of motion (7)
2 Primate of Madagascar (5)
3 First lunar phase (3,4)
5 Sound of something moving at speed (6)
6 Indefinite extent; utmost (3,6)
7 Distance in units equivalent to 0.91 metres (7)
8 Inventor of the ZX Spectrum home computer (5,8)
14 Build-up of bile deposits (9)
16 Belief that there is no god (7)
18 French science-fiction film of 1962 (2,5)
19 Production of visual representations (7)
20 Group of fish (6)
23 Metal grid or grate (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #198

set by Bethan Ackerley

1 Which of the following aren't a type of algae: diatoms, bikonts or stoneworts?

2 Which two major continental landmasses combined to form Pangaea?

3 What was the first non-spherical moon to be discovered?

4 Organisms within the same genus are known as what?

5 What is the popular name for the ancient human remains found in Goat's Hole cave near Swansea, UK, in 1823?

Answers on page 55

Puzzle

set by Katie Steckles

#218 Playground parity

I was eating a sandwich on a park bench when a horde of children from the local school descended on the playground in front of me and divided into two groups.

I couldn't help overhearing the kids by the swings shout across to the kids near the climbing frame: "If two of you run over here, our group will be double yours!"

The kids by the climbing frame replied: "But if two of you come over here, the groups will be the same size!"

The mathematician in me couldn't resist figuring out how many children there must be in each group for this to be true. But I also discovered something else. If a number of children going one way makes one group double the other, and that same number going the other way makes the two groups the same, the total number of children must always be a multiple of... what?

Solution next week

Fiddly fingers

Most violinists use their left hand for intricate fingerwork, so why is the right hand used for more complex key pressing on the piano?

Peter Sheppard Skærved
London, UK
As a violinist, I can say that the right hand and arm executes more complicated sets of movements than the left. These are almost too many to enumerate: combining up and down bow motions and complex voicings (up to four strings played at once), pressure downwards on the strings from arm weight and/or muscular tension, bow angle (which controls how many of the bow hairs are in contact with the string) and articulation, the impossible-to-count possible beginnings and endings of notes.

What's more, there are the hundreds of different bowing combinations that are necessary to control the timbres, colours, tone and syntax that the bow (which is always in motion, and with no consistent point of reference) has to produce in even the simplest music.

"It shouldn't be a surprise that a number of great left-handed violinists played with their violin held the other way round"

It shouldn't be surprising that a number of great players who were left-handed, such as Rudolf Kolisch, played with their violin the other way round. The dominant hand needs to control the bow.

As for the piano, I can't help you there!

BIM/GETTY IMAGES

Would it be possible for a mountain twice the height of Everest to exist on Earth?

This week's new questions

Height restriction **What governs the maximum height of mountains on Earth? Could a mountain as high as Olympus Mons on Mars (21.9 kilometres, more than double the height of Everest) be possible on our planet?** ***John Howes**, Cardiff, UK*

Latin accent **Do we actually know how the ancient Romans pronounced Latin words?** ***Richard Lachlan**, Sydney, Australia*

Jerry Whitman
Barnham, West Sussex, UK
Early instruments were for accompanying singers. Lutes, mandolins and guitars required intricate plucking, which was carried out by the more dexterous hand. The pitch of the strings was determined by frets across the fingerboard, so the less dexterous hand only had to "stop" the strings with fingers behind the frets, a much simpler task.

Viols still had frets, but also had bows. These instruments made the dexterous hand and arm's task more dynamic, which it is suited to. The transition to violin, which had no frets, made the less dominant hand more responsible for pitch (tuning) accuracy, but still didn't require as much dexterity as the bow. Don't underestimate how difficult it is to control a bow! Having established that pattern, the rest is history.

Keyboard instruments, however, evolved so that a player could play tunes and harmonies simultaneously. So the dexterous right hand needed access to the dominant higher-pitched notes and the left hand the lower-pitched harmonies with their less complex patterns, thus determining the keyboard orientation. I am not aware of any mirror pianos. What's more, over the centuries, the lower pitches have become more prominent and performing pianists are now equally dexterous with both hands.

Graham Jones
Norwich, Norfolk, UK
As an amateur violinist, I think the violinist's left hand probably has an easier job than the right. In the violin family, the left hand controls the exact pitch of the note. By contrast, the right hand controls the loudness, style and tonal quality of the note, all of which probably require finer motor control.

Most left-handed people play the violin conventionally, but a few play in mirror fashion, which requires the instrument to be built to suit. So those who are very powerfully left-handed can go to a lot of extra trouble to get a left-handed instrument.

Charles Henry
Greensburg, Pennsylvania, US
In most Western music, the melody lines are in the upper voices. The soprano and alto parts contain far more notes per measure on average than the tenor and bass parts. Those upper notes happen to fall to the pianist's right hand. Actually, it wouldn't seem to matter, because a number of great pianists have been left-handed, including Glenn Gould and Daniel Barenboim.

I have played the violin most of my life and found that left-hand finger placement is largely learned in the first few years of study. Sensitive bow control is a major technical difference between a very good player and a virtuoso. Mastery of bow technique is the work of many years.

Hiss off

Cats, geese and snakes hiss, and angry audiences hiss to make their feelings known. How is it that this "language" is common to such diverse creatures, as well as to those who understand the warning?

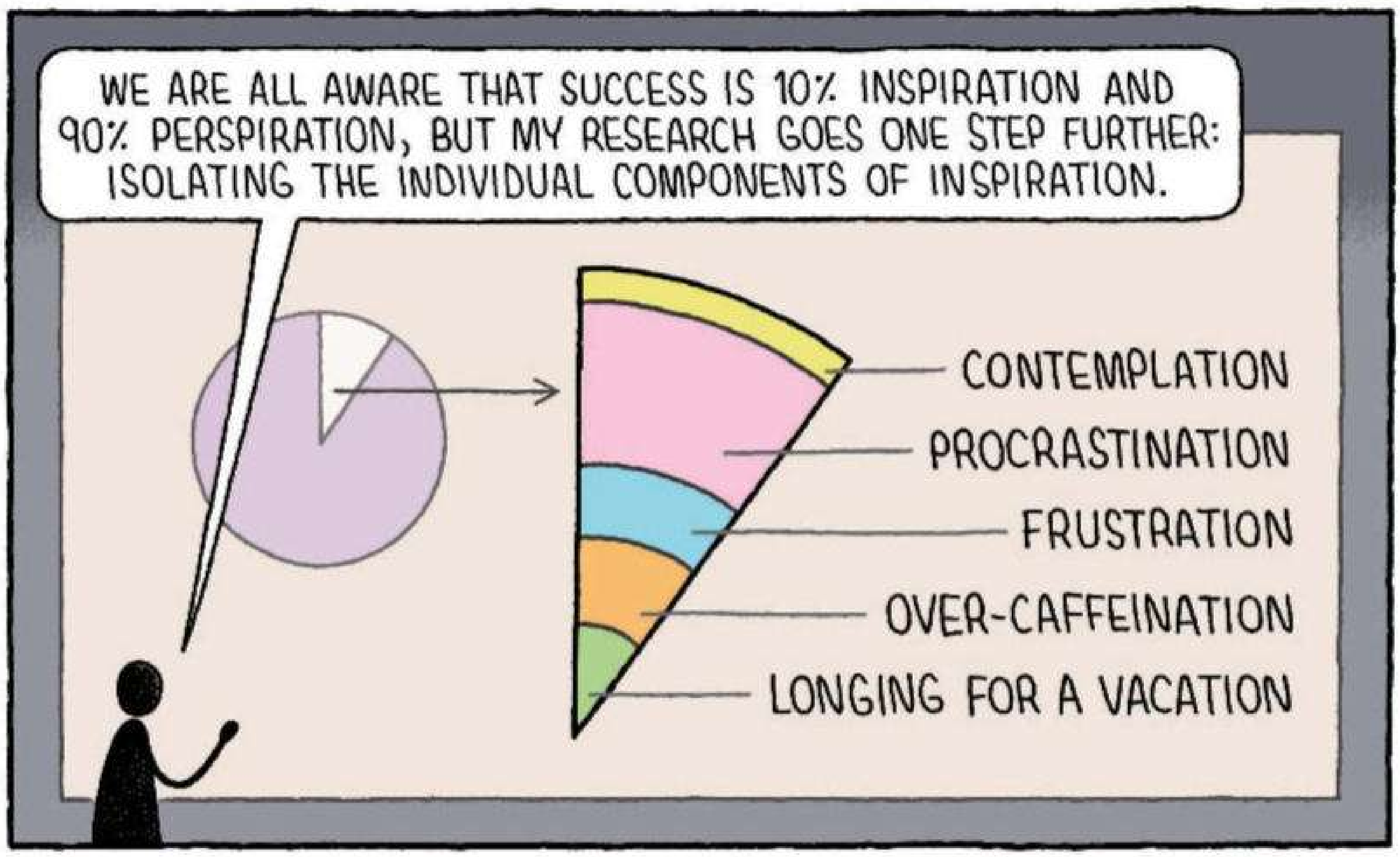
Gerald Legg
Hurstpierpoint, West Sussex, UK
Hissing has several uses. It is a method of communication when responding to fear or stress and is also a way to attract attention. In the animal world, it is often used as a warning to predators or unwanted suitors.

Humans have several forms of hiss: long and drawn out, expressing disapproval; short

Want to send us a question or answer?
Email us at lastword@newscientist.com
Questions should be about everyday science phenomena
Full terms and conditions at newscientist.com/lw-terms

Tom Gauld

for New Scientist


WE ARE ALL AWARE THAT SUCCESS IS 10% INSPIRATION AND 90% PERSPIRATION, BUT MY RESEARCH GOES ONE STEP FURTHER: ISOLATING THE INDIVIDUAL COMPONENTS OF INSPIRATION.
CONTEMPLATION
PROCRASTINATION
FRUSTRATION
OVER-CAFFEINATION
LONGING FOR A VACATION

and sharp, rising in frequency and almost finishing with "t", used to attract attention. While living in Sierra Leone, my wife and I found that people often used a short, sharp hiss to attract attention, especially in the markets. It was very effective and, to this day, I use it when I want to get my wife's attention in a store or other public, noisy place.

Hissing is also common in other cultures. In Korean culture, for instance, the "ssup" sound – made by drawing air inwards along the tongue – is used a lot. A 2022 paper, "Is it polite to hiss?", found this sound is more commonly used when addressing people who are social superiors, such as elders, and often occurs at trouble spots in conversations.

> **"Humans have several forms of hiss: long and drawn out to express disapproval; short and rising in frequency to attract attention"**

Sundowner

Is it possible to distinguish sunrise from sunset from an image (i.e. with no knowledge of the direction in the sky or time of day, and in a time frame with no discernible solar motion)? (continued)

Quentin Macilray
Poole, Dorset, UK

Speaking from experience in a previous incarnation on an early morning postal round, I can report that the colours of the early morning are incomparably more delicate and varied than those of the sunset. They range from grey to violet to subdued purplish to many shades of green and orangish and finally gold, and there are hundreds of gradations in between.

I have never seen this reproduced or even suggested in any work of art, and I suspect it is impossible to capture on film.

Graham Turner
Dunedin, New Zealand

Your correspondent John Welford (18 March) expresses doubt about the depiction of a sunset in the painting *The Fighting Temeraire*, set on the river Thames, by J. M. W. Turner (no relation).

In the northern latitude of London, the sun's daily path from east to west traces an arc in the sky, from left to right, centred on the south point of the horizon.

So has Turner shown a sunrise or a sunset? Cleverly, he has also shown the crescent moon, to the left of the sun, and higher in the sky. Since the sun and moon follow (roughly) the same path, we must be looking at the right-hand end of the arc: a sunset in the west.

As your correspondent points out, the symbolism is powerful – the sunset of a sailing vessel as the Temeraire is towed to the breaker's yard by a scruffy little steam-tug.

Alas, from my perspective in the southern hemisphere city of Dunedin, New Zealand, this painting depicts a sunrise, since the eastern end of the arc is at the right. The symbolism is shattered, and I see instead the sunrise of commercial steam. Not at all the message Turner intended. ▮

Answers

Quick quiz #198
Answers

1 Bikonts
2 Gondwana and Laurasia
3 Hyperion, a moon of Saturn
4 Congeners
5 The Red Lady of Paviland

Cryptic crossword #107 *Answers*

ACROSS 1 Stick insect, **8** Nascent, **9** Nasal, **10** Solid, **11** Rebuffs, **13** Cation, **15** Deduct, **17** Perigee, **18** Throw, **20** Lumen, **22** Grasped, **23** Planet Earth

DOWN 1 Sinus, **2** Insulator, **3** Kneed, **4** Nature, **5** Ennoble, **6** Tis, **7** All set, **12** Fluorspar, **13** Cupola, **14** Organza, **16** League, **18** Trade, **19** Width, **21** Map

#217 Vicious circle
Solution

Neville can potentially escape. If he starts from the centre of the circular island and tries to run directly away from the monster to the other side of the moat, it will be able to catch him because it can swim half the circumference (πr) faster than he can run the radius (r). But if he is careful, Neville can keep the centre directly between himself and the monster as long as he is within a quarter of the circle's radius. This is because he can run around this smaller circle ($\frac{1}{2}\pi r$) in the same amount of time that the monster can swim the outer circle ($2\pi r$).

If Neville does this right, he will still be on the opposite side to the monster after traversing a quarter of the circle's radius. Once he has run from there to the moat ($\frac{3}{4}r$), the monster will still have about $0.14r$ left to swim, leaving a sliver of time to jump across and escape.

Spacey superpowers

Some people have a superior knowledge, and maybe control, of space and direction. That is evident in the harvest from Feedback's call to identify trivial superpowers – a person's ability to reliably do some particular task that seems mundane to them, but that most people find impossible to do except once in a while by sheer luck. Also evident, in the views expressed by some harvesters, is that other people have an inferior knowledge.

Martin Pettinger says: "I almost always can sense which direction is north (or east/west/south) without looking at a map or the sun. My children can also do it, but my second wife and her family, and apparently others, cannot."

Jan Horton says: "I have always been aware of where I was in relation to compass headings. On an ocean liner en route from Australia to New Zealand, I woke distressed in our inside cabin because we were going the 'wrong way'. My husband was not aware of a problem, but when we went on deck it was to find we had indeed turned back – in search of a missing crew member – and were on a reciprocal course."

Twisteddoodles *for New Scientist*

THE UNIVERSITY NEED YOU TO HIGHLIGHT YOUR RESEARCH ON SOCIAL MEDIA
I'M NOT REALLY ON IT, SORRY!
OH THAT'S GOING TO HAVE TO CHANGE...
WE HAVE WAYS OF MAKING YOU TIK TOK
@twisteddoodles

Got a story for Feedback?

Send it to feedback@newscientist.com or
New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

Timely superpowers

Other people have a superior knowledge of time. These time-related abilities may be the most beneficial of trivial superpowers.

Bonnie Packert says: "I have no idea whether this is common. I shared this 'talent' with my father but have not heard from others who could do the same. When I set an alarm to wake up, I usually awaken just before it goes off, within a minute or two of the set time, maybe as much as five minutes early. It is nice not to have to listen to the blaring and to leave my partner sleeping peacefully."

George Greider says: "I have a strangely unerring sense of time. I can wake up at whatever time I choose to the minute. Either in the morning or from a nap. When I put something in a microwave or other appliance with a timer, I am walking towards it when it's done regardless of the time setting."

Earle McNeil says: "I have never had to use an alarm clock to wake up at any required time in the morning. In fact, when I don't have my hearing aids in I could not hear it anyway."

Life in triplicate

While perusing the latest crop of research news about estimating mesocarnivore abundance on commercial farmland using distance sampling with camera traps, Feedback happened across a paper by three researchers from Durham University, UK, who happened across some *Caracal caracal caracal*.

***Caracal caracal caracal* is, it is perhaps needless to state, one of several species that have been graced with a triple tautonym for their formal scientific name.**

A tautonym is a name – for some particular kind of animal, plant, alga, fungus or whatever – that has the same word for both genus and species. A triple tautonym has that same word repeated a third time for the subspecies.

***Caracal caracal caracal* brought to mind *Bison bison bison*. *Bison bison bison* triggered memories of *Bufo bufo bufo*. *Bufo bufo bufo* led, inevitably, to recollections of *Bubo bubo bubo*. The floodgates thus opened, in poured many old friends. Among them: *Naja naja naja*, *Pica pica pica*, *Redunca redunca redunca*, *Natrix natrix natrix*, *Gallus gallus gallus*, *Giraffa giraffa giraffa* and good old *Gorilla gorilla gorilla*.**

Three-parters and two-parters sometimes dwell near each other in the wild, as one sees in a 2020 report in *Biology Bulletin* about the presence of *Caracal caracal caracal* and *Lynx lynx* in Turkey.

Tautonymicity aside, when repetitive-name dropping, it is mite-y polite to mention *Scheloribates repetitus* and *Scheloribates multirepetitus*, which are, each of them, as near as mites get to being tautonymic.

Man sniffs dog

A twist on the old joke about "man bites dog" is playing out in homes where well-groomed dogs live together with (presumably) well-groomed people. "Dog Cosmetics: Another unexpected source of allergen exposure" reads the headline of a report in the journal *Contact Dermatitis*.

Authors Livia Francine Soriano, Shannon Kimberly Soriano and Deirdre Buckley surveyed "all 163 dog cosmetic products sold face-to-face in five high street pet stores in Southampton, UK", paying special attention to the lists of ingredients. The majority of the listed cosmetics include stuffs explicitly called "parfum", "perfume", "fragrance" or "eau de toilette". The report's list of what is listed includes citrus grandis extract, linalool, limonene, the lyrically named methylchloroisothiazolinone/methylisothiazolinone, alongside other delights. A few products, sold without info about their component substances, yielded only a whiff of mystery.

Soriano, Soriano and Buckley say the UK and the EU have no requirement for ingredient labelling for pet cosmetics. The trio withhold all lurid detail about the dangers, opting instead to state a plain warning: "Dog cosmetics are poorly labelled, contain chemicals banned in human cosmetics, and gloves should be worn to handle them."

The authors also withhold any discussion of an opposite set of problems: the hazards to allergen-sensitive dogs, who daily breathe the intimate nearness of perfumed people. ▮

Marc Abrahams

GALAXY
ON GLASS

SPECTACULAR WALL ART FROM
ASTROPHOTOGRAPHER CHRIS BAKER

SPECIAL OFFER!

10% Discount on all images for New Scientist readers.
Use the code NEWSCIENTIST at checkout.

www.galaxyonglass.com
chris@galaxyonglass.com | +44 (0)7814 181647

Shop at omegawatches.com

SPEEDMASTER MOONWATCH

In July 1969, the Speedmaster earned its nickname when it became the first watch worn on the moon, and in 1970, it went above all expectations when it helped guide the crew of the crippled Apollo 13 mission back to safety. Updated today as a Co-Axial Master Chronometer, the iconic Moonwatch is now tested and certified at the highest level by the Swiss Federal Institute of Metrology (METAS) - which guarantees more accuracy, reliability and supreme resistance to magnetism.

Ω
OMEGA